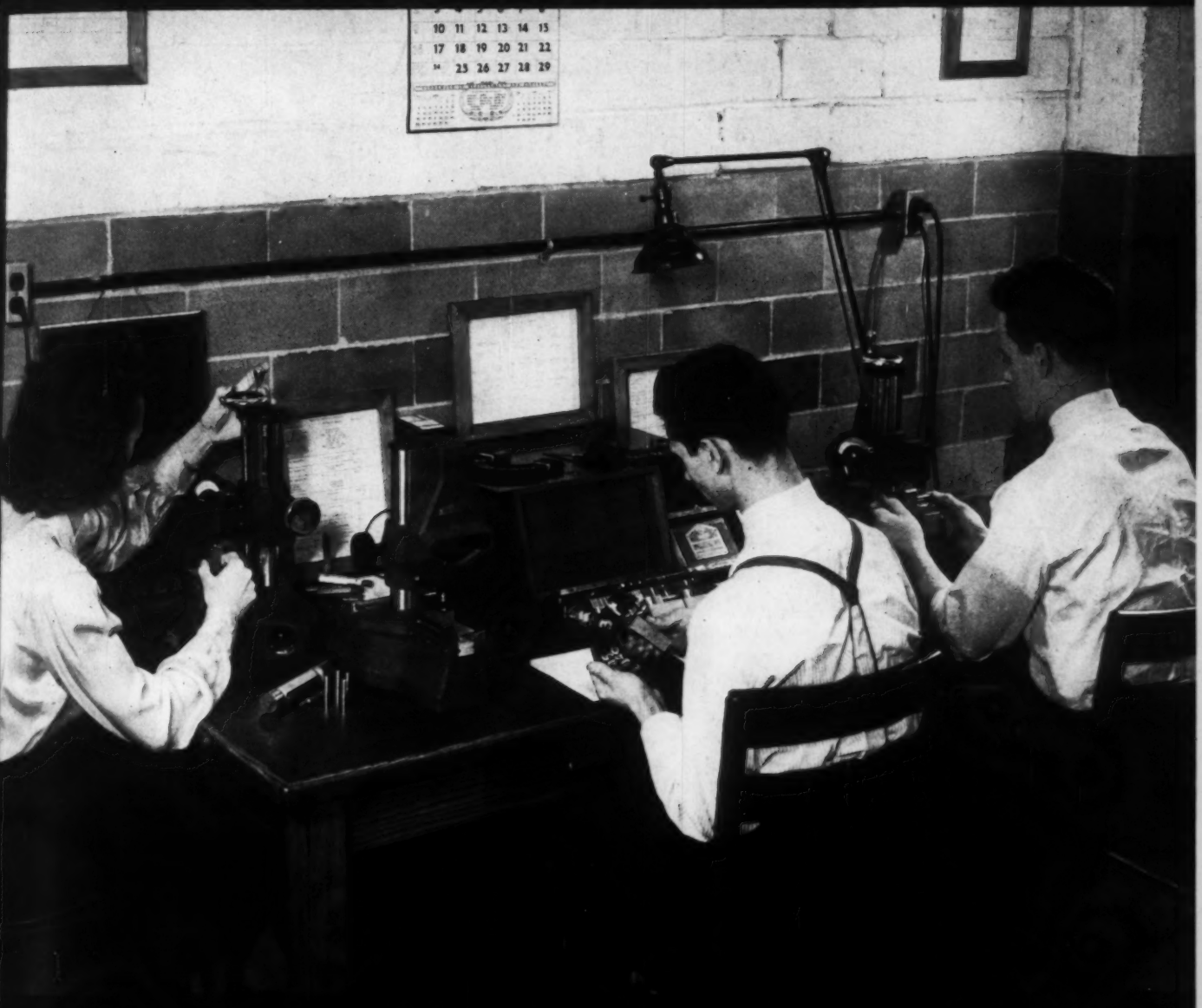
Instruments

THE MAGAZINE OF

Measurement and Control

Vol. 16
JUNE
1943
No. 6



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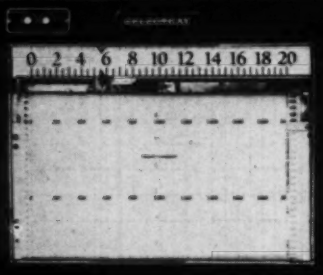

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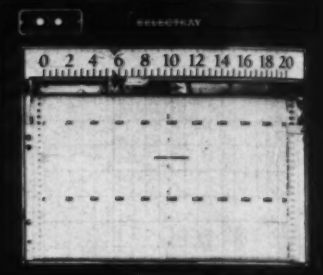

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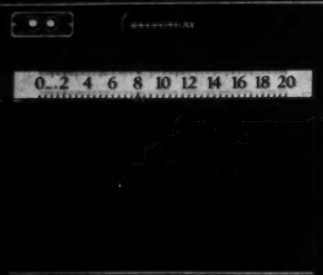

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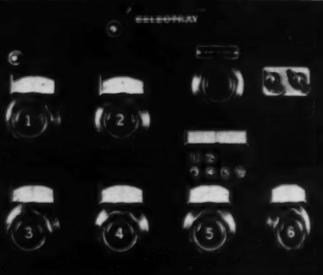

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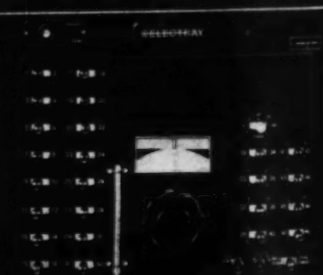

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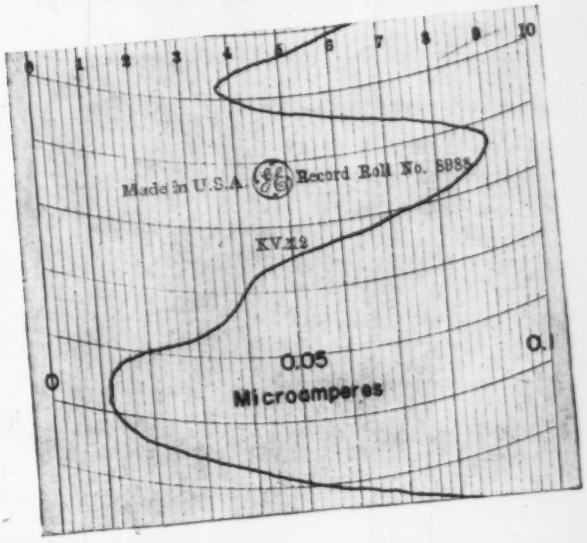

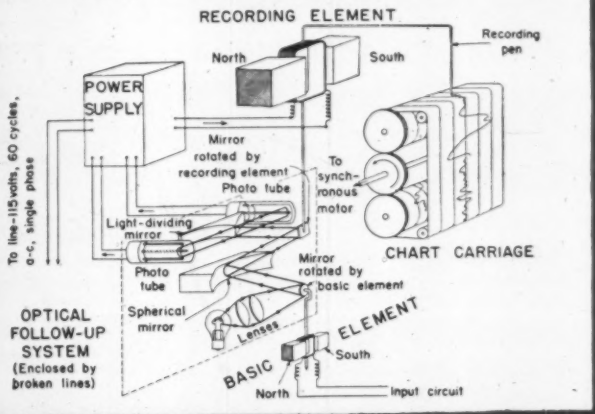

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THE internal parts of this photoelectric recorder are the basic measuring element, the optical follow-up system, the electronic power supply, the recording element, and the chart carriage. The basic element is the only measuring device in the recorder. Its load is the only one imposed on the input circuit.

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High-speed recording	Equipment tests

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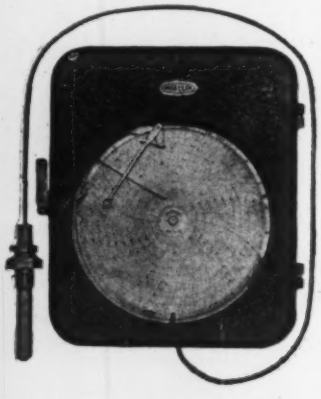

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Instruments THE MAGAZINE OF *Measurement and Control*

M. F. BEHAR, Editor

Chem & Met Does It Again!

IN April 1929, on the occasion of the Twelfth Exposition of Chemical Industries, *Chemical & Metallurgical Engineering* brought out a special issue which was in reality the first technical-magazine symposium on Process Control. Seven of the twenty articles were specifically on "instrumentation" (though the term wasn't used) and the other thirteen dealt at least in part with instrumental control. These twenty articles occupied 62 pages. That special issue gave Instrumentation its first big impetus.*

Now *Chem & Met* has done it again in its May 1943 issue, with a 48-page section entitled "Measurement and Control of Process Variables." And what a splendid "repeat performance"! Any 31 of these 48 pages contain better information than did the 62 pages fourteen years ago. But we must restrain our enthusiasm and report that while the 1929 achievement both summarized much existing knowledge and added to it, this 1943 achievement summarizes a far greater body of knowledge without adding to it. What this 48-page section is, as a whole, is a sort of highly-condensed "manual of instrumentation" for chemical industries. In fact, the longest article, "Instruments for Measurement and Control of Process Variables," a remarkably meaty 17-page review by the "editorial staff" (which we believe means Ted Olive), is arranged almost exactly like THE Manual which appeared serially in *Instruments*,** that is to say, in conformity with rational methods of classification. This same devotion to methodical condensation and presentation is apparent in most of the other articles:

"Fundamental Principles of Automatic Control" (10 pages) by J. C. Peters, Leeds & Northrup Co., and T. R. Olive, Associate Editor of *Chem & Met*.

"Automatic Control Terminology" (⅔ p.) by Editorial Staff.

"A View into the Next Decade in Industrial Instruments" (3⅓ p.) by W. B. Heinz, consulting engineer and Cochrane Corp. representative.

"Considering Controllability in Plant Design" (3½ p.) by E. D. Haigler, Foxboro Co.

"Selection Factors and Operating Characteristics of Control Valves" (4½ p.) by R. E. Olson, Taylor Instrument Companies.

"Pneumatic vs. Electrical Automatic Control" (2⅓ p.) by E. L. Stilson, The Bristol Co.

"Instrument Application Progress in Process Industries" (5⅓ p.) by Editorial Staff.

From the titles our subscribers will gain a correct general impression, so we need not undertake a detailed analysis or individual reviews of all eight articles. Many of our older subscribers have met the five outside contributors, who are instrument-company engineers specializing in the design and application of automatic controllers: five *real* "experts" in their field—as are Ted Olive and his associates in theirs! The whole is a thoroughly workmanlike job.

And yet we doubt that this compact little mine of useful information will make one-tenth of the stir that *Chem & Met's* first symposium did fourteen years ago. One obvious reason is that it is not the first of its kind. Another reason is that many technical journals have increasingly featured instrumentation since the early thirties. For example the A.C.S. *Industrial & Engineering Chemistry* has had two special issues with instrumentation sections by Professor Ralph Müller: 60 pages in Oct. 1940 and 88 pages in Oct. 1941. And we've lost count of the total number of pages in *Transactions A.S.M.E.*, *Transactions A.I.Ch.E.* and *Transactions A.I.E.E.* devoted to the numerous papers on instrumentation subjects presented in recent years before these national engineering societies! But out of all this profusion of technical-journal literature on instruments, only this second *Chem & Met* symposium, arranged and in part written (as was the first one) by Ted Olive, stands out as a well-rounded and wide-scope compendium—touching upon ALL important process control subjects. That's why we joyously shout "*Chem & Met* Does It Again!" —MFB

*This statement is made deliberately and without overlooking the fact that in January 1928 there had appeared the first issue of a monthly magazine called *Instruments—Industrial—Scientific* (the name of which was changed in 1932 to *Instruments—The Magazine of Measurement and Control*)! Yes, that April 1929 issue of *Chem & Met* did more to advance the science of process control than—well, perhaps more than did all the issues of all technical journals published throughout 1929!

**Having leaned over backward in the first footnote, we now inform our loyal subscribers that every major subject in this new symposium has been adequately covered in *Instruments*. Again leaning the other way, we add that the issues of *Instruments* containing the original source material (Handbook of Industrial Instruments, 1930-31, Manual of Instrumentation, 1932-37, etc., etc.) are out of print, so that the condensed versions in the May *Chem & Met* are a great convenience.

Invent the "Post-war" *Now!*

ONE of our rules has been to give little space to "personals" and none to those about instrument-company executives. The bigger the company, the less chance there was for mentions of its officers. In short, the exact opposite of venal newspapers which rate department-store and drug and food and industrial "big shots" (and their wives and daughters!) in proportion to the advertising dollars they command. Thumbing through back files of *Instruments* discloses that the only personal items about prominent instrument makers have been their obituaries! "We" (the editor) do not apologize but "I" (the human being) think "we" may have passed up some items of genuine interest to subscribers.* And why should "we" treat as complete strangers men whom "I" know and respect? Anyway, "we" received from Board Chairman Richard P. Brown of Brown Instrument, a carbon copy of the Commencement Address he is to give to the graduating class of Drexel Institute Evening School; and "I" consider it an inspiring message. It is inspiring because (1) it is not ghost-written but lovingly prepared by Mr. Brown himself; (2) Mr. Brown eschews generalities and gives sound conclusions based on (*a*) his decades of experience at Brown Instrument from the time it was "a small instrument business with one employee" through its growth largely due to his inventions, (*b*) his experience as Regional Consultant for the Defense Plant Corporation.

"You are graduating at a time when the world is on the threshold of new and important developments which will make life more wonderful, more enjoyable and more complete. . . . I have in mind the millions of new and better homes which must be built to house our people, the demand which will exist for new and better automobiles . . . and countless other articles . . .

Concluded on page 390

*Perhaps subscribers would have been pleased to read an item every time that Henry Warren of Warren Telechron received another science medal or started another crusade for better treatment of skilled labor; or when President Cunningham of Republic Flow Meters made up a stronger team of "progressives" to fight the "reactionaries" in the N.A.M.; or when President Redding of L&N was re-elected President of the Franklin Institute; or when contributions to science and industry were made not by the "engineers" (to whom "we" have never grudged space) but by the "presidents" of big instrument companies—even though most of these "presidents" were formerly (or *are*) the Chief Engineers or Production Managers or Research Directors of their companies.

An Emergency Liquid-Level Controller

By EARL M. SEAGRAVE
Instrument Dept., Celanese Corp. of America, Rock Creek, Va.

IN an emergency, a few spare parts and a moderate amount of ingenuity can produce a stop-gap device that will serve its purpose as well as a factory-made instrument. There is no necessity of stressing the fact that the less we call on the manufacturers for instruments we can do without, the more they can devote themselves to producing instruments for jobs where there can be no substitutes. Hence the advisability of using the materials at hand whenever possible.

A case in point is the instrument we made recently to replace a float-actuated air-operated liquid level controller

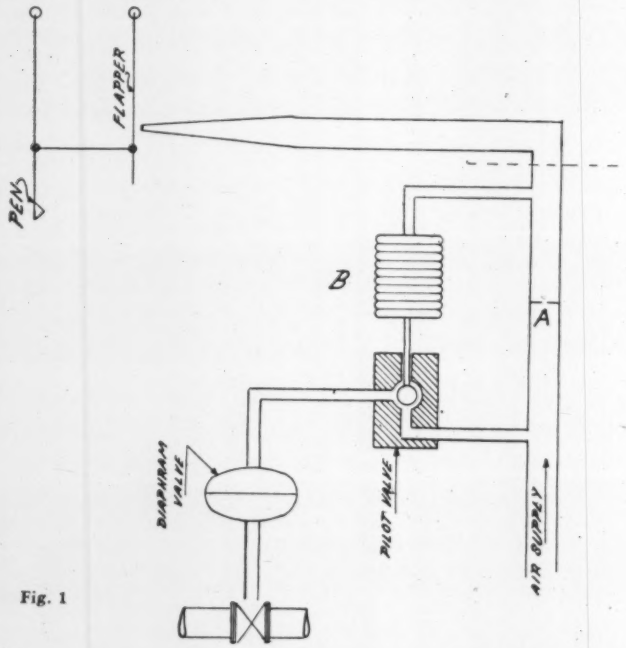


Fig. 1

which was to hold the level in a small open tank by positioning a 6″ air-to-open diaphragm valve.

This controller had to be removed because it operated through such a narrow throttling range that, at certain loads, cycling occurred which caused undesirable and even dangerous pressure surges in the tank supply lines.

The problem was then to find a controller with a moderately wide throttling range that would be simple, cheap, dependable and could be made from the materials on hand. We chose from our stock of replacement parts an air-relay or pilot-valve assembly made for a typical air-operated controller of the nozzle-and-flapper type. A brief discussion of the familiar principles involved in this class of controllers will show that the pilot-valve assembly is, in itself, a simple pressure controller.

In Fig. 1 we have a flapper which either covers or uncovers an air nozzle, depending on the pen position. When the nozzle is covered the air bleeding into the nozzle through restriction *A* cannot escape, hence the pressure on the pilot-valve operating bellows increases and the pilot-valve stem is moved to a new position which changes the output pressure. Or, when the flapper is moved away from the nozzle the air in the nozzle system escapes and since orifice *A* is smaller than the hole at the nozzle tip, the pressure in the pilot-valve operating bellows is decreased and the output pressure is changed in the other direction. This means that the pilot-valve assembly is a controller that can be made to position a diaphragm valve in response to pressure changes in bellows *B*.

Level measurements can be made, of course, by measuring the back pressure on a pipe, one end of which is submerged in the liquid, when air is introduced into the pipe and allowed to bubble up slowly through the liquid.

Therefore, using the pilot-valve mechanism as a controller and the bubble pipe as a primary element, we can construct a controller which will position a diaphragm motor. It so happened that the air-relay we used had an output pressure gage and a restriction built as integral parts so all that remained to be done was to determine by test what pressure change on the pilot-valve bellows was necessary to change the output pressure from zero to supply pressure, or, in other words, to determine the throttling range. This value in pounds was converted into equivalent feet of water and the bubble pipe was cut so that the desired level would fall roughly into the center of this span. When the bubble pipe

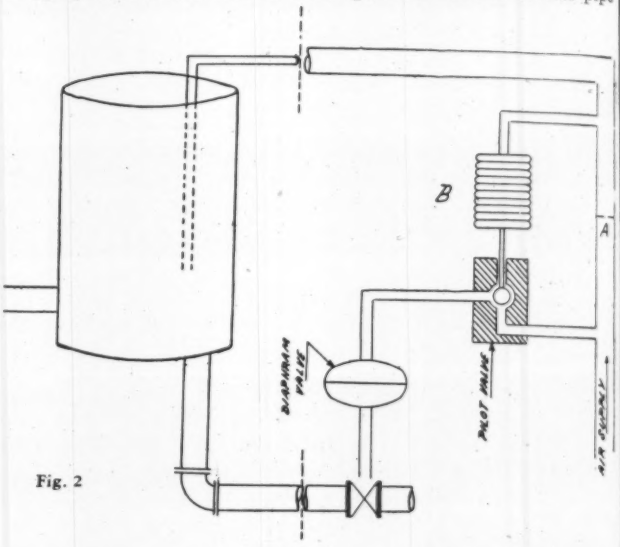
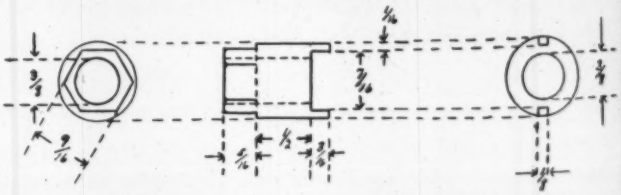


Fig. 2

was connected as shown in Fig. 2 the restriction built in the air-relay served to throttle the air to the bubble pipe and the bellows *B* moved the pilot-stem in response to level changes, thus controlling the tank level without violent surges. We found that a level change of nearly seven feet was required to change the controlled valve from fully open to fully closed when the air supply was set at 20 lbs./in.^{2}. Some throttling range adjustment can be effected by changing the tension of the diaphragm spring and the supply pressure together.

Special Wrench for Switchboard Instruments

By RALPH BLANKENSHIP
Public Service Co. of Indiana Inc., New Castle, Ind.



TO the instrument repairman, who repairs instruments for power houses or substations: In the Type H5 instruments, the studs are made fast to the insulators by a round nut, which has two slots for some kind of a special wrench. The drawing herewith is the wrench I made, which will remove or tighten this nut—a real time-saver.

Fig. 1. General view of the Standards Room. In the front-cover photograph (Fig. 1A), Standards Room employees Eva Frye, Frank Vosnick and Thomas Farrell are shown using small Pratt & Whitney and Sheffield Comparators. These are adjusted and set with gage blocks.

Standards Provide Accuracy, Boost Production, Cut Costs in Mass Production

By W. S. POTTER

Assistant Works Manager, Pittsburgh Equitable Meter Co., Pittsburgh, Pa.

FEW technical developments in recent years have contributed so largely to the progress of manufacturing accuracy and mass production as has the modern application of the principle of standards. Comparatively little of the importance of standards, gages, and dimensional control is known outside the shops where these principles are applied, but to those who are closely associated with their functions—designers, engineers and inspectors—the standard is an exacting and unbending law.

Its general definition is simple. Standardization is essentially agreement on definitions. A standard is an established regulation adhered to by a specific faction whose common need brought about its inception. In most cases the need had to be critical indeed, as is suggested by the extremely slow rate of progress in universal standardization, until recent years.

> It is *not* by accident that this article appears in the same issue as Captain Bowman's on gage laboratory equipment. "We planned it that way."

It is easy to understand early failures to organize and establish a general system of standards. There simply was no need for one until the dawn of interchangeable manufacture. At the close of the eighteenth century the manufacture of guns for war finally sounded the cry for industrial standardization. Eli Whitney, then owner of an arms factory, found it necessary to effect interchangeability in making his gun parts, both for mass production and as an efficient means of parts replacement, Although his development of rules and gages was remarkable for the times, Whitney's efforts—as well as those of other pioneering industrialists of his day—failed to achieve a system of reliable master standards until half a century later. Even then, production measurement lagged behind laboratory

Fig. 2. The operator, Frank Vosnick, is taking a reading at the Pratt & Whitney Measuring Machine. The drum reads direct to 0.00001".

Fig. 3. Pratt & Whitney Standard Measuring Machine, showing a "go" and "not go" thread gage in place for checking the pitch diameter. The wire sets used for this purpose are visible in the right foreground.

Fig. 4. The hardness of a form tool is being checked by Thomas Farrell with a Rockwell Tester made by Wilson Mechanical Instrument Co.

precision until the beginning of the present century.

Today, interchangeability and rapid assembly of parts is a reality, thanks to our highly developed system of gaging. In order to make a part which will assemble with a remote mechanism, it is necessary that the dimensions of mating parts be known. In order to know these dimensions, we must have reliable standards and precision gages made to these standards. Development of highly accurate equipment for gaging not only has made for speed and greater adaptability, but serves to increase the service life of machines and provide innumerable other economies.

STANDARDS IN OUR INDUSTRY

Proof of the adaptability of standardization to the meter, regulator and valve industry is revealed in the establishment by the Pittsburgh Equitable Meter Company of a complete and modern standards department. Under normal conditions we are the world's largest manufacturers of gas and liquid meters and gas pressure regulators. These products are made in a complete range of sizes and types to handle any domestic or industrial service.

Accuracy in our mass-produced measurement and control equipment is of necessity dependent upon the accuracy of the tools, jigs and particularly the gages that guide the machining and assembly procedure. Absolute interchangeability of parts is not only a requirement for properly building new meters but also a "must" in repair and maintenance work. Many of our smaller customers have only limited repair facilities and testing equipment for proving the accuracy of repaired meters. Even minor discrepancies in the dimensions of replacement parts can produce major errors in measurement.

Before Pearl Harbor, most domestic meters were obsoleted on a twenty-year life span. Now, with meter production practically stopped, many of these "old timers" are being given a new lease on life with accurately made and fitted replacement parts. With the close controls made possible through our Standards Department, it is now feasible to refit an old meter casing with interchangeable replacement parts and produce an even better testing meter than when new.

IMPORTANCE OF DIMENSIONAL CONTROL

The Pittsburgh Equitable Meter Company Standards Department grew out of the normal demand for manufacturing accuracy as well as farsightedness on the part of officials and department heads directly interested in dimensional control. When our Inspection Department was reorganized several years ago, establishment of an adequate Standards Room was begun at once since it was apparent that before many years the maintenance of this department would be an essential to the demands for accuracy and volume in production.

In the hands of our Standards Room personnel rests the responsibility of procuring and maintaining gaging equipment of the highest degree of accuracy. This company's achievements, particularly in handling wartime projects to the strictest specifications, is proof that this responsibility is borne well.

Gaging equipment is procured from firms which deal principally in the manufacture and sale of these products. Our experience indicates that it is wise to maintain adequate testing equipment for proving new gages as well as for providing a constant check on gages already in use. Our Standards Room is fitted with the best equipment available for these purposes. A constant temperature of 68°F. is maintained in the insulated quarters by a Westinghouse Unitaire Conditioner. This temperature assures normality in metal expansion or contraction while gages and parts are being tested.

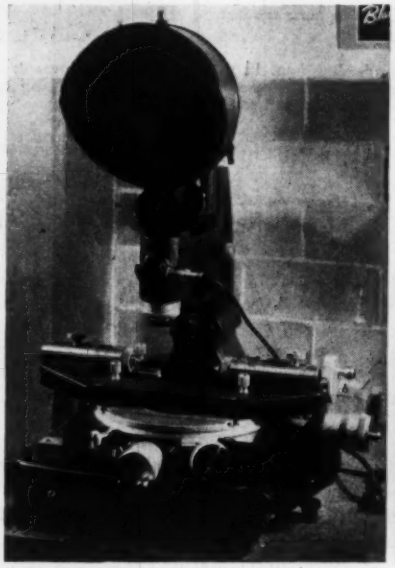


Fig. 5. The Zeiss Toolmakers' Microscope in use checking a production part for correct contour against the standard outlined on the projection screen.

Fig. 6. A newly purchased tap is being checked in the Zeiss Toolmakers Microscope by Thomas Farrell using an ocular in which are incorporated accurate thread form standards.

STANDARDS EQUIPMENT USED

To aid in obtaining accuracy in measurement our Standards Room maintains the well-known Pratt & Whitney Measuring Machine. This device, used as a means for checking gages, tools and parts, reads directly in hundred-thousandths of an inch. It consists essentially of a master bar, a dividing screw, and a means of controlling measuring pressure; all mounted on a rigid bed. The master bar is graduated at each inch interval, providing a permanently accurate setting. The graduations are extremely fine hairlines, visible only through a microscope. The measuring head includes a microscope, with two hairline graduations used when setting to match the hairline on the master bar, and a precision dividing screw which subdivides one inch.

Our Zeiss Large Toolmaker's Micr scope, Figs. 5 and 6, is used for che ing shapes and measuring profiles such items as gages, shaped tools, c ters, templates, cams, curve plat thread gages and taps, and threadi tools and cutters. The work to be test is brought into a beam of light fr an illuminating source, and the silho ette so formed is examined and mea ured microscopically. In the image pla of the microscope ocular is a gla plate containing either a suitable ma for comparing the measurement poin of the test piece, or standard outlin (such as frequently-recurring threa and profiles) for comparison with t silhouette. For checking frequently changing profiles for which no standar figures are available, the silhouette o the test piece may be thrown on a screen which carries an enlarged draw ing on transparent paper. Likewise, a enlarged drawing of a profile tool ca be made. Magnification is adjustable to either approximately 10 to 1 or 3 to 1.

Similar in function to the Zeiss Tool maker's Microscope is our Jones & Lamson Pedestal Comparator and Measuring Machine. Its utility is based on the principles of the magnified pro file screen and horizontal or latera measurement, these uses being illus trated in Figs. 7 and 8.

Two Pratt & Whitney Electrolimit External Comparators are maintained for measurement of external gage and parts surfaces. The principal components of these machines are the anvil, the measuring spindle which has a diamond gaging point with a flat surface of 1/32", and an ammeter or indicator which provides the reading. By means of a master standard the comparators

set to the desired sizes; then the
t piece is compared to that master
ndard by being brought into contact
th the measuring spindle. This in
rn changes an electric circuit in such
manner that the deviation is shown
a greatly magnified form on the am-
ter. Being comparatively small and
ht, the External Comparator can be
nsported at will and used at shop
chines and in final product inspec-
n as well as for gage-checking.

THE GLASS SURFACE PLATE

Other machines and devices in use in
e Standards Room include a Sheffield
sual Gage, a Rockwell Hardness
Tester, and a Glass Surface Plate. The
onstruction of this Surface Plate was
uggested by the writer and developed
y Mr. Frank Saveker, our Supervisor
f Quality Control. At the time of this
late's inception, the metal shortage
ecessitated searching for substitute
urface plate material, and experiments
with 1¼" thick glass resulted in the
rst glass surface plate made. At the
resent time all our plates are made of
lass. Our experience has shown that
hey are less expensive than metal, that
heir accuracy is equal to the best metal
lates obtainable, and that they are
ore durable in that scratches leave
nly a slight groove with no damage to
atness. Manufacturing rights for these
lates were obtained from this company
y the Delta Manufacturing Company
f Milwaukee.

GAGES PURCHASED AND MAINTAINED

As has been pointed out, our Stand-
ards Room is primarily interested in
he determination, purchase, and main-
enance of gages suited to our produc-
ion needs. The principal types of gages in use at present are thread plug, ring thread, cylindrical plug, snap, and flush pin depth gages. In some of the machining departments gages are checked regularly every eight hours by equipment in the Standards Room. A complete gage filing system is maintained to record gage wear and life and, in addition, to provide a means for supplying replacements as needed.

Advantages and possibilities resulting from the establishment of this department are innumerable. It has stepped up and simplified production. It has minimized rejections and scrapping. It has made possible our acceptance of war contracts and sub-contracts calling for extremely high manufacturing precision and accuracy. It has minimized the obstacle of unskilled labor in wartime by transferring responsibility from men — and particularly women—to machines that are accurately checked against known standards.

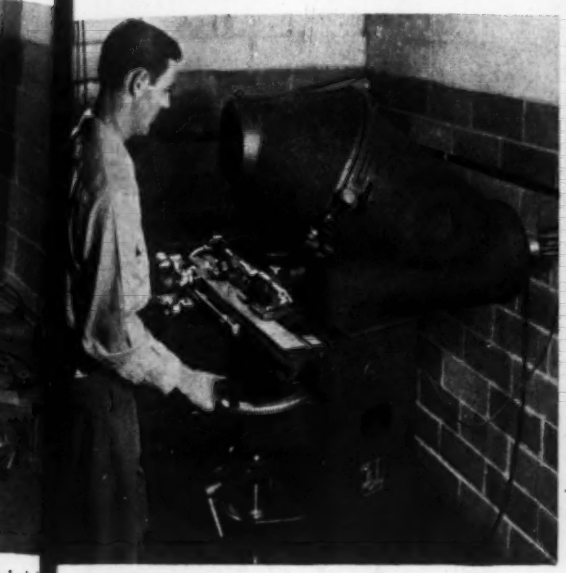


Fig. 7. Jones & Lamson Pedestal Comparator and Measuring Machine being operated by Edward Joyce. In the machine a tap is receiving a periodic examination for wear after use.

Fig. 8. Tap thread form projected on screen of Jones & Lamson Comparator.

A large part of this company's facilities has been converted to the manufacture of war materials. Some of these products are oxygen regulators, armor-piercing shot, pillow blocks, aircraft posts, a vehicle axle member, airplane gasoline heater equipment, an observational trainer and fuze mechanisms.

DIMENSIONAL CONTROL VITAL TO WAR PRODUCTION

Perhaps the most interesting of our products for war is an oxygen regulator, manufactured in a special division of our plant. This intricate instrument's function is to control the flow of oxygen to flying personnel. It is actuated only by the normal breathing of the aviator using the instrument.

Contrary to general precision instrument assembly practice, the oxygen regulator is put together and tested on a streamlined assembly line, operated by women, with excellent results. In fact, large scale production of this regulator would be impossible by reason of the shortage of skilled labor were we to follow the individual assembly practice normally used on instrument manufacture. By our method, each individual in the line is assured of receiving parts that assemble properly because of their having been checked by gages whose dimensional control rests in the hands of our Standards Department.

We have recently been awarded the Army Air Forces' "A" Rating for Quality Control in the manufacture of this oxygen regulator. Naturally, our Standards Department merits a great deal of credit as it is directly responsible for this manufacturing supremacy.

POST-WAR STANDARDS PLANS

Post-war plans of the Pittsburgh Equitable Meter Company highlight extensive utilization of our Standards Department. This company operates two large factories in the Pittsburgh district, the Equipment in the bulk of which comes under the direct supervisory control of the Standards Department. As subsidiary firms we have the Merco Nordstrom Valve Company in Oakland, California, where production of lubricated plug valves tops that of any other firm; The National Meter Company of Brooklyn, New York, a 78-year-old firm, manufacturers of liquid meters; and the H. A. Smith Machine Company of Hopewell, New Jersey, which has exceptional facilities for screw machine and light assembly work. In Hopewell many parts are fabricated for the other Divisions of the organization.

Manufacturing control, made possible through our Pittsburgh Standards Department, is even now indirectly providing a superior quality of production at these other plants. New gages purchased for any of these Divisions are shipped first to the home factory where they are subjected to tests in the Standards Room for finished accuracy before reshipment to the ultimate user.

It is now realized that the lessons learned from seven years in standards control at Pittsburgh apply equally well to our other plants. Our hope and expectation is that, following the war, with equipment again available, we shall be able to place in operation standards departments in all our subsidiary firms.

Frank Saveker, Supervisor of Quality Control, is advisory head of the Pittsburgh Equitable Meter Company Standards Department. Operations in the Standards Room are supervised by Edward Joyce, with Thomas Farrell, Frank Vosnick, Frank Larimer, James Hamilton and Eva Frye assisting.

ELECTRON TUBES

Their Principles and Their Instrumentation Applications

By ANDREW W. KRAMER

Managing Editor, *Power Plant Engineering*, Chicago, Ill.

CHAPTER II

Since an electric current is in reality a flow or drift of electrons through a conductor, and since this flow may be maintained by an electric generator or battery, we may ask how can such a flow of electrons be stopped without stopping the generator. In the case of a hydraulic system the mere closing of a valve in the line is sufficient to stop the flow of water. As the valve closes, the area through which the water flows is gradually restricted, allowing less water to pass and finally when the valve is completely closed the flow is stopped entirely.

The electrical condition is somewhat similar. Here also it is necessary to interpose in the line some sort of a barrier through which the free electrons cannot pass. All that is necessary is to place an insulating material at some point in the circuit. The easiest way to do this is to break the circuit at that point and pull the ends far enough away

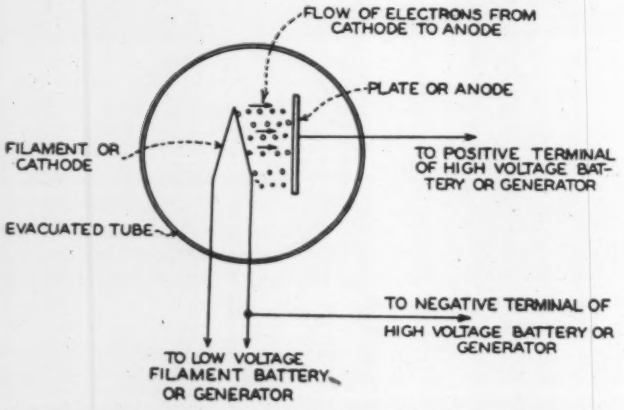

FLOW OF ELECTRONS FROM CATHODE TO ANODE
PLATE OR ANODE
FILAMENT OR CATHODE
TO POSITIVE TERMINAL OF HIGH VOLTAGE BATTERY OR GENERATOR
EVACUATED TUBE
TO NEGATIVE TERMINAL OF HIGH VOLTAGE BATTERY OR GENERATOR
TO LOW VOLTAGE FILAMENT BATTERY OR GENERATOR

Fig. 2. Fundamentally the vacuum tube consists of an incandescent filament and a metal plate mounted inside an evacuated glass or metal envelope.

from each other so as to interpose a certain amount of air between them. Air at atmospheric pressure is a good insulator and since it instantly flows into the break it effectively stops the flow of electrons, and the full electrical pressure (voltage) which caused the flow appears between the free ends vainly trying to re-establish the flow. Such an arrangement is provided by an ordinary knife switch in air.

Here again it is extremely fortunate that the atmosphere in which we live does not contain many free electrons under normal conditions. For if it did we would not be able to break even the weakest electric current by opening a switch in air. As it is, there are enough free electrons in air to make the action difficult where high voltages are used.

At ordinary voltages, say below 500 or 600 volts, an "air break" switch operates effectively but at high voltages difficulties arise: the current tends to flow even after the conductor is broken. An arc appears at the break. Often this arc must be drawn out to an appreciable length before the current is interrupted.

We shall not attempt, here, to explain the nature of this arc or how it is formed, for, as implied before, it is a complicated phenomenon* and is not essential to an understanding of the electron tube. The fact that an arc of this kind forms, however, seems to indicate that, under certain conditions at least, electrons may flow through a gas, for air may be regarded as a gas at ordinary temperatures.

*J. Slepian. Theory of the Electric Arc. *Journal of the Western Society of Engineers*, April, 1928.

Apparently, then, under certain conditions free electrons have the power of leaving the metals in which they normally exist, and passing out into materials which ordinarily are classed as nonconductors or insulators. In Fig. 3 is shown the simplest form of lightning arrester. It consists simply of a gap—a spark gap—one side of which is attached to the power or telephone line and the other side connected to the ground. Normally, the voltage on the line is insufficient to force electrons out of the conductor into the air gap but when lightning strikes the line the voltage

HERE it is at last—the serial you want. Of all subscribers' suggestions, the most insistent have been for more articles on electron tubes in Industrial Instrumentation. It did us no good to recommend special magazines and textbooks: they insisted there was no book written for them—for you. So here it is.

Mr. Kramer's long experience has included designing and applying electronic instruments.

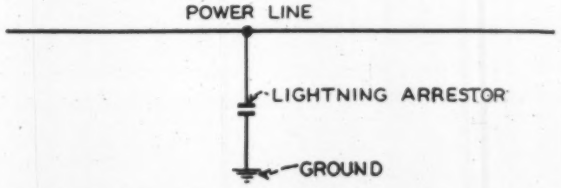


Fig. 3. Simplest type of lightning arrestor which acts as a kind of a safety valve for relieving excess electrical pressure.

rises to such a high value that the air gap breaks down and the current flows across the air space to the ground. As the lightning surge expends itself in this manner, the voltage decreases until finally it can no longer keep the electrons out in space and they scamper back into the conductor and so terminate the flow. Thus, an air gap of this kind acts just as a safety valve on a boiler.

About three quarters of a century ago, it was discovered that if two terminals were sealed into the ends of a glass tube and the tube exhausted of air, an electric current could

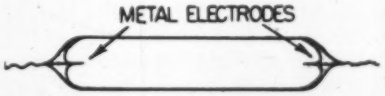


Fig. 4. Many years ago it was discovered that if two terminals were sealed into the ends of a glass tube and the tube exhausted, an electric current would be made to pass across the space inside.

be made to pass across the space inside. This required relatively high voltage but, as in the case of the spark gap, it also showed that—as we would say today—electrons can leave the metal terminals and pass across a space occupied only by rarefied air.

These were our first vacuum tubes, at least they were called that. They were not called electron tubes because the electron had not been discovered. They were really not vacuum tubes because they still contained appreciable quantities of gas.* Under certain conditions they would glow with beautiful colors but they were little more than curious playthings. It was realized that something curious was going on inside these tubes but few realized that they con-

*No tube referred to as a vacuum tube is really a true vacuum tube because even after such a tube has been exhausted by the most refined methods known to science, it still contains countless millions of atoms of gas.

tained the embryo of the most amazing discoveries of the next half-century.

Electric current flows through such tubes in either direction, the polarity of the terminals making no difference. The current, furthermore, is extremely small, even with high voltages, but the fact that current flows at all is quite remarkable—at least it was considered remarkable at the time these effects were first noticed. At that time the electron theory of electricity had not been established and there was no logical thory available to account for it.

Another phenomenon which could not be explained was discovered by Edison about 1882, long before anybody knew anything about electrons. In developing the incandescent lamp Edison noticed a curious phenomenon which occurred when he placed a small metal plate in the bulb of a lamp as shown in Fig. 5. When the filament was heated to incandescence, Edison found that the plate became charged electrically and if it was connected through a galvanometer to the positive terminal of the filament, a current would be indicated. When the plate was connected to the negative terminal, however, no current would flow. Apparently, the presence of the hot filament in some mysterious way produced a charge on the plate.

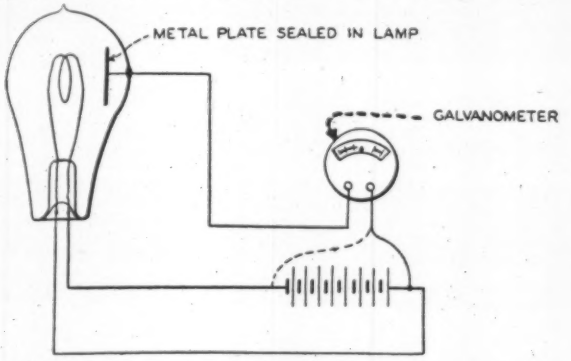


Fig. 5. Edison noticed a curious phenomenon when he placed a small metal plate in the bulb of a lamp. When the filament was heated, the plate became charged electrically and if it was connected through a sensitive galvanometer to the positive terminal of the filament, current would flow.

That hot bodies produced electrical effects had been known before; indeed for a hundred years it had been known that when a metal is heated red hot the air in its immediate vicinity becomes a conductor of electricity, but this still did not explain the "Edison effect," as it was called, and for a long time this effect remained a mystery. For a time it was more or less forgotten.

In time, however, more became known about the nature of electricity and the electron theory was evolved. This for the first time provided a clue regarding the mechanism of electric conduction and also offered an explanation of the Edison effect. According to the electron theory, it was quite possible that when a metal was heated to a high temperature as in the case of a filament, electrons might be "boiled" out of the metal, so to speak, and projected out into space, just as molecules of water are projected out of the surface of a vessel of boiling water.

This is actually the case: In metals, at high temperatures, the molecular activity of both the atoms and free electrons is greatly increased and certain of the free electrons acquire sufficient velocity to enable them to overcome the restraining force at the surface and they are thus projected out into space. As early as 1899 J. J. Thomson had shown that negative electricity was given off from the hot filament of Edison's lamp in the form of electrons but the mechanism of this emission was not known until O. W. Richardson in 1901 showed that the electrons are emitted solely by virtue of their kinetic energy.

The random movement of the free electrons in a conductor exerts a pressure, just as the kinetic energies of the molecules in a gas manifests itself as a pressure. At ordinary temperatures this pressure is not sufficient to enable electrons to escape from the metal into the surrounding space because there are attractive forces at the surface that

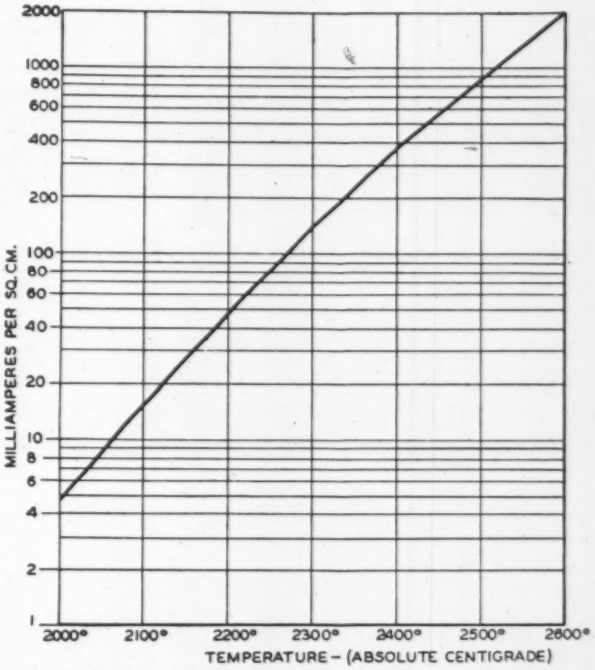


Fig. 6. Graph showing how the electron emission from tungsten varies with the absolute temperature. In this case the electron emission is given in milliamperes. Since one milliampere is equal to 6,280,000,000,000,000 electrons, the total number of electrons emitted per square centimeter can be arrived at by merely multiplying by this factor.

tend to keep the electrons in the conductor and these forces are much greater than the pressure of the "electron gas." At ordinary temperatures, few electrons in the more common metals possess sufficient kinetic energy to overcome these forces at the surface and the number of electrons escaping at such temperatures is negligibly small. At any particular moment some electrons will have zero velocity while others will have high velocities. The majority, however, will have velocities between the two extreme values of speed. At ordinary temperatures only those few electrons with the extremely high velocities are able to escape through the surface.

To escape from the surface of a conductor an electron must do a certain amount of work to overcome the surface forces and this energy can be obtained only from the kinetic energy possessed by the electron as a result of its motion. Unless the kinetic energy of an electron exceeds the work that an electron must perform to overcome the surface forces, the electron cannot escape. It is for this reason that a rise in temperature aids the process of escape. As the temperature of a body increases the average kinetic energies of the molecules and electrons increase, until a point is reached where a considerable number will have sufficient kinetic energy to escape through the surface.

We must not confuse this process of electron evaporation with the evaporation or rather the vaporization of metals. The evaporation of electrons occurs at a lower temperature than that at which evaporation of atoms occurs. This is due to the fact that the average velocity of the electron is much higher than that of the atom. We would, therefore, expect to obtain a copious emission of electrons at a temperature considerably below the boiling point of the metal and this actually is the case. Fig. 6 shows how the electron emission from tungsten varies with temperature.

Having explained the manner in which electrons are emitted from metals, it is possible now to begin a detailed consideration of the electron or thermionic tube. This process of "boiling" electrons out of metals is known as the thermionic effect—that is, it is the production of "ions" by "thermal" agitation. Electrons (ions) can be released from metals in other ways also; for example by merely pulling them out by means of extremely high potentials, but the thermionic method is by far the simplest and results in the release of the greatest number. This phenomenon, which

was regarded at first merely as an interesting fact, is responsible for perhaps the most startling developments in the realm of electricity—indeed it is the foundation of the whole modern art of electrical communication. Without electron emission from hot filaments there would be no thermionic tubes and without thermionic tubes there would be no radio broadcasting and receiving, or telegraph and picture transmission as we know it today. Nor would there be countless electrical control devices in industry which we have today.

CHAPTER III

Electron tubes are made in a great variety of types and sizes, and for a variety of purposes but the fundamental principles involved in all of them are the same. All have a cathode which serves as a source of electrons and one or more additional electrodes for controlling or receiving these electrons. The electrons are drawn across the space between the cathode and other electrodes and this passage of electrons represents the current through the tube. The electron emission from the cathode may be produced in various ways. In the thermionic tube it is brought about by heat; by raising the temperature as already explained. In the photoelectric tube, it is accomplished by the action of light, indeed, the concept of the photoelectric tube originated nearly sixty years ago when Hertz noticed that one of his spark gaps would break down more easily when illuminated on its negative electrode. In certain other types of tubes other methods are employed in producing the electron current, but these are of a special nature and need not be discussed now; for the present only the thermionic type of tube will be considered.

The simplest thermionic tube consists simply of a hot cathode and an anode, usually called the *plate*, sealed in an evacuated bulb. Such a tube is called a *diode*, the family name for two-element tubes. (Tubes containing more than two essential elements will be taken up in later chapters.) As will be explained more fully below, a diode containing only a heated cathode and a plate is, fundamentally, a rectifier—a non-return valve in an electric circuit. Current can pass through the tube in one direction but not in the reverse direction. When the tube is connected into a circuit containing a battery or other source of potential, and if the connections are made so that the plate is positive with respect to the cathode, electrons boiled out of the cathode by the heat are attracted and absorbed by the plate. When the polarity is reversed, however, and the plate is made negative with respect to the cathode, nothing happens, since the plate is cold and therefore does not emit electrons.

This is all that there is to the matter, and this really is all that need be considered in this chapter. If you stopped reading at this point, insofar as the fundamental principle of the two-electrode tube is concerned you would understand it perhaps as well as if you read the rest of this article. If, however, you feel that you would like to know a little more about the actual relations between cathode temperature and the voltage across the tube or how the tube is connected into a circuit, it is suggested that you read on. There are a number of interesting things about the action of the tube which should be understood. Consider the cathode, for example: how is it heated and what form does it take?

The cathode may be heated directly or indirectly. For example, a directly heated cathode usually is simply a wire

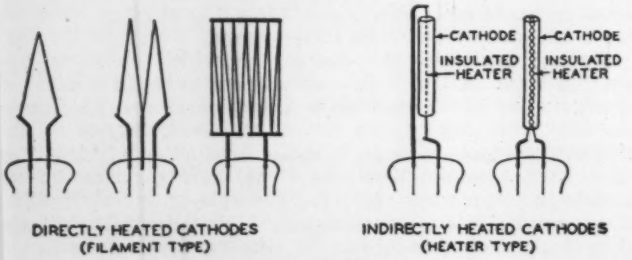


Fig. 7. Types of Cathodes.

heated by the passage of an electric current, similar to the filament of an ordinary incandescent lamp. The filament of an incandescent lamp actually does emit electrons in this way. An indirectly-heated cathode consists of a filament or heater enclosed in a metal sleeve. The sleeve carries the electron-emitting material on its outside surface and is heated by radiation and conduction from the heater. Insofar as the actual mechanism of emission is concerned, the principle in both directly- and indirectly-heated cathodes is the same.

The cathode is an essential part of any electron tube since it supplies the electrons necessary for the tube's operation. When the cathode is heated, electrons are liberated from the surface and are projected into the space beyond, forming a sort of invisible cloud around the cathode. The air is removed from the tube to permit the free movement of the electrons and to prevent the disintegration of the cathode surface by the active molecules of oxygen.

If there are no other influences acting in the tube, the electron cloud surrounding the cathode remains unchanged so long as the cathode is maintained at a definite temperature. Electrons are continually being emitted but as many fall back into the cathode as are emitted, so a balance condition ensues. The reason for this will be clear upon a moment's reflection. Before the temperature of the cathode is raised, it may be considered electrically neutral, that is, it possesses no electric charge of any kind. When electrons are liberated, however, the cathode as a whole is left with a deficiency of electrons and since electrons represent negative charges, the cathode exhibits a slight positive charge and tends to draw back into its surface the electrons which have been emitted. Thus, at any instant, as many electrons are drawn back into the cathode by this positive charge as are emitted by reason of the thermal effect. The higher the temperature of the cathode, the greater will be the speeds and the kinetic energies of the electrons leaving the surface and the greater will be the extent of their travel before they fall back, but in any case a condition of equilibrium will be attained and the only effect of the higher temperature will be a greater radius of the electron cloud. Such a condition actually exists in an ordinary tungsten lamp, for in such a lamp the filament is heated to a sufficiently high temperature to produce copious electron emission.

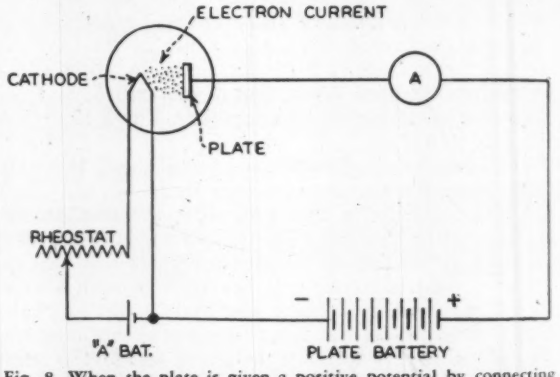


Fig. 8. When the plate is given a positive potential by connecting it to a battery, electrons emitted by the hot cathode are drawn across the intervening space between cathode and plate.

Suppose, however, that a positively charged metal plate is introduced into the tube, as is the case in the diode. As shown in Fig. 8, this positive charge is imparted to the plate by connecting it to the positive terminal of a battery or direct-current generator, the negative terminal of which is connected to the cathode. The electrons are negatively charged, hence they are attracted by the positively charged plate. Under the influence of the positive potential, the electrons surrounding the cathode are drawn to the plate and return through the external battery circuit to the cathode, thus completing the circuit. This flow of electrons is called the *plate current* and it may be measured by suitable ammeters just as any other electric current. It was this plate current that Edison detected in his early lamp experiments though he did not realize its implications.

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Note to Industrial Executives: *The problems solved by Sola "CV" transformers in other plants may have an exact counterpart in yours. Find out. Ask for bulletin GCV-74.*

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The strength, or value, of this plate current, as may be suspected, is dependent upon two factors: first the temperature of the cathode, and second the value of the positive potential applied to the plate. When the cathode is cold, the tube forms an absolute barrier to the flow of electricity through the circuit, even though the full potential of the plate battery is impressed across it.

Assume, however, that the cathode is gradually heated (by cutting out resistance in the filament circuit). As the temperature rises, a point will be reached where electrons will begin to be emitted from the metal in accordance with the principles described. As they emerge they will be drawn to the plate under the action of the positive plate potential and the plate current will be established. At first this current is extremely small because only comparatively few electrons are liberated. As the cathode temperature is increased, more electrons are emitted, and, as a consequence, the plate current increases. If the plate current is plotted against cathode temperature a curve such as that shown in Fig. 6 will be obtained. This shows clearly that the plate current is definitely related to the cathode temperature.

The number of electrons reaching the plate, however, is also dependent upon the value of the positive plate potential. The higher the positive potential, the more intense will

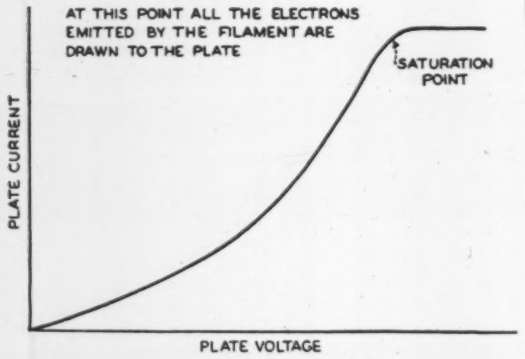
AT THIS POINT ALL THE ELECTRONS EMITTED BY THE FILAMENT ARE DRAWN TO THE PLATE
SATURATION POINT
PLATE CURRENT
PLATE VOLTAGE

Fig. 9. Variation of plate current with variation of plate voltage.

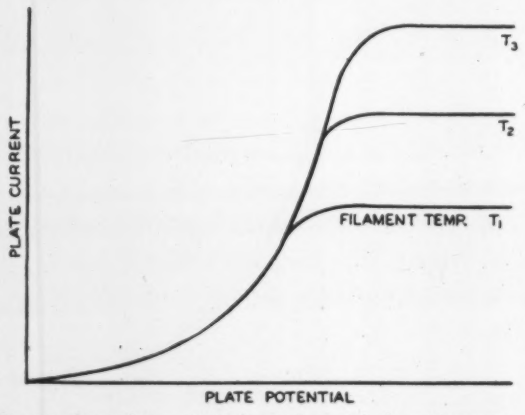

Fig. 10. Saturation currents for various cathode temperatures.

be the attractive force acting on the electrons and the more rapidly will they be drawn to the plate. Thus, with the filament temperature held at constant value, as the plate potential is slowly increased from zero, the number of electrons drawn to the plate also increases.

If the increase of plate potential is continued, however, a value will be reached at which all of the electrons emitted by the cathode are attracted to the plate. When this value is reached, any further increase in plate potential will cause no further increase in plate current. This is known as the saturation current. If the value of the plate current is plotted against plate potential, a curve of the general shape shown in Fig. 9 will be obtained.

The saturation current so obtained is that corresponding to a definite cathode temperature only. A further increase of cathode temperature brings about a further increase in the number of electrons emitted and as a consequence a new saturation current is established. So, for each cathode temperature there exists a corresponding value of saturation current. In each case, this saturation current represents the value of plate potential where all of the electrons emitted by the cathode are drawn over to the plate.

The next paragraph may be skipped by readers not trained in mathematics:

Since the saturation current is a measure of the number of electrons emitted by the cathode for a certain temperature, the value of this current can be calculated by means of the general equations given by Richardson for the number of electrons emitted by hot bodies. Richardson's original equation is as follows:

$$N = AT^c e^{-b/T}$$

in which N is the number of electrons emitted per second, A, b and c are constants depending upon the nature of the cathode substance and T the absolute temperature. e is the base of the natural system of logarithms. In the case of an ordinary tungsten filament, the constant c in the above formula is ½. Then, the saturation plate current I for a given filament temperature T in a tube having a perfect vacuum, is given by the equation

$$I = A\,Te^{-b/T}$$

where A, b and e have the same meaning as above.

Having these relationships between cathode temperature, plate potential and plate current clearly in mind, let us now consider briefly a simple though fundamental application of the two-electrode tube in electric circuit.

So far, we have considered only the action of the tube when a positive potential is applied to the plate. Suppose now, instead of a positive potential, we apply a negative potential to the plate by connecting it to the negative terminal of the battery as shown in Fig. 11. It is quite evident

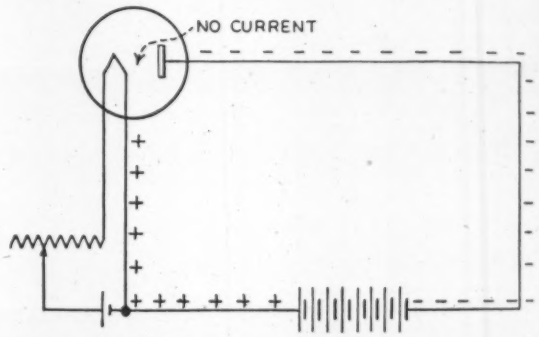

Fig. 11. When the plate is charged negatively no current flows through the tube.

that under these conditions no current can flow, for now any electrons that might be emitted by the cathode are immediately forced back into the cathode by virtue of the powerful negative field exerted by the plate. And since the plate is cold, it cannot emit electrons. Thus, the tube permits electrons to flow from the cathode to the plate when the plate is positive but not from the plate to the cathode when the plate potential is reversed. The tube, therefore, acts very much as a non-return valve in a piping system, permitting current to flow in one direction but not in the reverse direction.

Continued on page 366

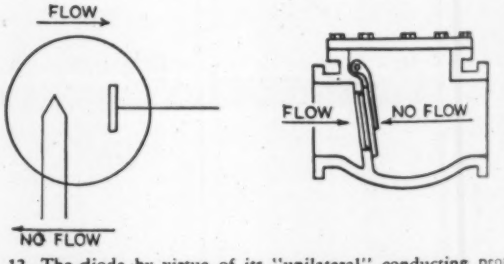

Fig. 12. The diode by virtue of its "unilateral" conducting property is similar to a non-return valve in a piping system.

VANT TO MEASURE THE INDIVIDUAL COMPONENTS OF A COMPLEX WAVE?

Model 300A will do this and make many another measurement.

ariable selectivity feature makes this instrument outstanding . . permits measurements that would otherwise be impracal. Examples: measuring distortion of sound recordings on lm, disc and in other cases where there may be slight freuency modulation; integrating noise spectrum in acoustic easurements or for other purposes where a wider pass band ives a more representative integration. The wider pass band ermits more rapid measurement of filter characteristics in the aboratory or in production. The maximum selectivity is sufficient for measurements as low as 30 cycles.

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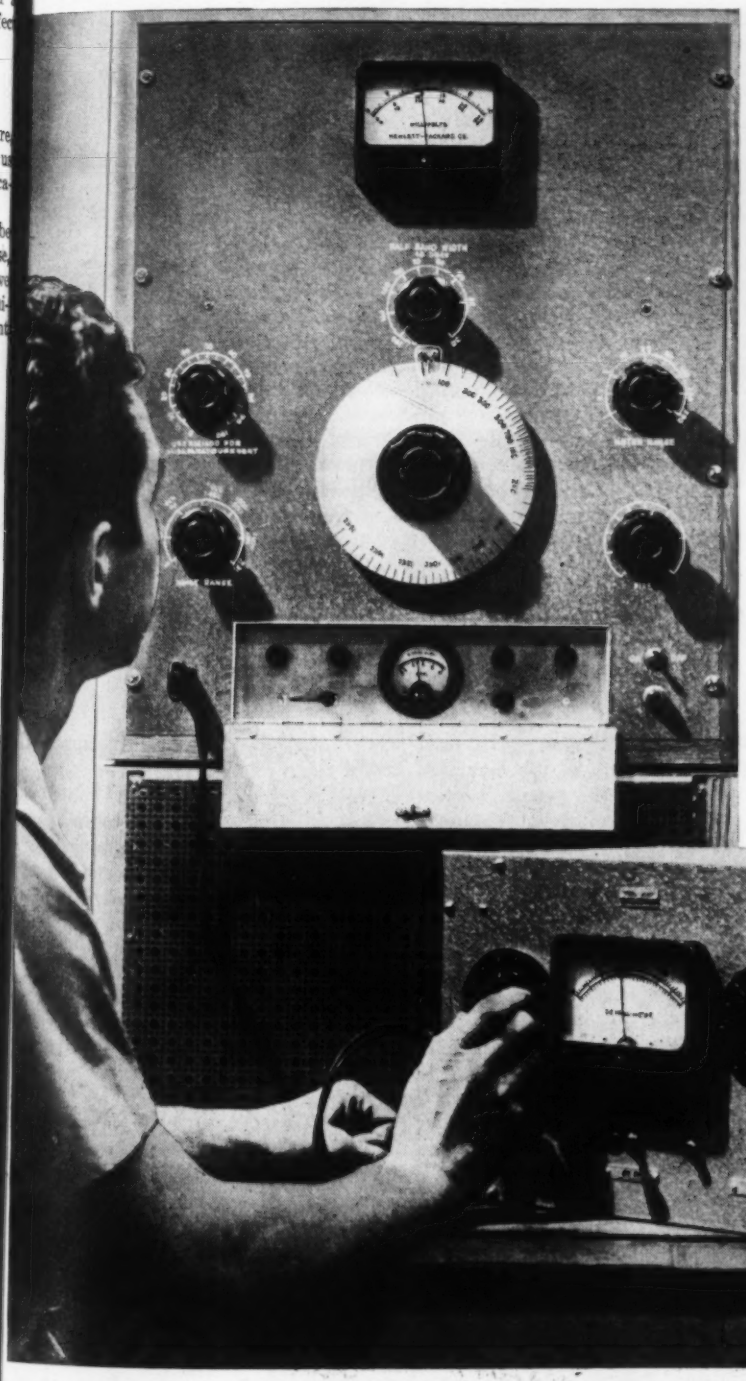

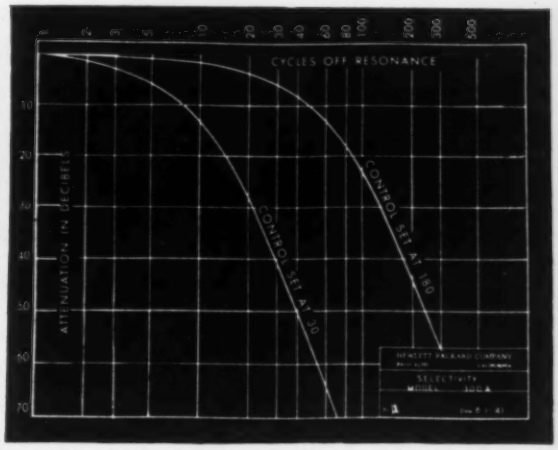

The selectivity characteristic of the Model 300A wave analyzer is shown above. The band width can be changed to any value between these curves by a turn of a knob

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Instrument Pivots and Bearings

By M. F. BEHAR

The following sections were omitted from last month's article because of lack of space. They are for maintenance personnel only.

4. Sensitivity Tests as Pivot and Bearing "Inspection"

The foregoing notes on inspecting pivots and bearings should not lead to unnecessary rejections. Always bear in mind that the specific mission of your crew is related to the degree of sensitivity expected from the instruments you service—not to the ideal sensitivity of imaginary instruments.

Thus, the field inspection of pivots and bearings must differ from their factory inspection. In addition, the inspection of pivots and bearings of instruments exposed to continuous vibration must differ from the inspection of pivots and bearings of instruments that will not see rough service. The first purpose of field inspection is to verify that the instrument will be serviceable and reliable under its conditions of use. When vibration is an ever-present condition of use, it sometimes improves the ultimate sensitivity of an instrument. For example, an instrument with several minor flat spots on both its pivots may not pass the usual slow-increase and slow-decrease test for "sticking"; but it may pass perfectly if it is vibrated during this test. The same is probably true of an instrument with minor defects in its jewel cavities: on a vibrationless table it may show a considerable zone between ascending and descending pointer readings, but on a vibration table it may show no hysteresis loop at all.

This is not stated as a general rule but as one of the differences to bear in mind. An obvious general rule is that a method should suit the type of instrument and the type of service. Another general rule is that the end-play adjustment should suit the degree of sensitivity required of the instrument under actual service conditions.

By applying these principles, men of long experience and exceptional skill are often able to "inspect" pivots and bearings without looking at them—by observing the exact behavior of the instrument pointer during various routine tests for sensitivity and accuracy. One of the "trade secrets" is similar to the balance test of an assembled mechanism removed from the case. Another involves holding the instrument in various positions while testing for sensitivity. The only reason this is mentioned here is because, if it were not mentioned, too many men would, too early in their experience, hear about its being done—and would think they could do it. Even the real experts cannot do it consistently. True, these tricks can save precious time; and dismantling an instrument to get at its pivots and bearings is exasperatingly slow work; but nothing takes the place of direct inspection by trained eyes examining the surfaces through an adequate magnifier, with correct illumination. Indirect inspection as a side-line of routine tests is justified, of course, when the shop is overloaded and a responsible higher authority orders that the instruments be merely checked as either serviceable or unserviceable. Indirect inspection by non-experts is justified only when a vitally important time limit has been set by a responsible higher authority, or is suddenly set by the pressure of events. Without direct inspection it is impossible to guarantee that pivots and bearings will not fail during the next week—or during the first hour of service.

VIII. Notes on Effects of Vibrations

Vibration engineering is so "deep" a subject that not even the experienced head of a large instrument maintenance organization can be expected to have studied its details. Since vibration plays an important part in the performance of pivots and jewels, a few notes are in order:

Vibration injures fine mechanisms and sometimes results in total failure.

The amount of vibration ("amplitude" or distance) is less important than the velocity—specifically the *acceleration.*

The practical unit of acceleration is "gravity." This is already familiar to personnel connected with Air Forces. A rough idea may be given as follows:

Hollow your hand and place a pencil stub on it. Move your hand up and down, faster and faster, until the pencil "floats" momentarily at a certain point in the cycle. Note that to keep your hand away from the pencil during any downstroke, you must move your hand down faster and faster, but it seems easier to make it float when reversing from up-stroke to down-stroke. Thus, whenever your downward acceleration is less than gravity, the pencil stays on your hand; but whenever your downward acceleration is greater than gravity, the pencil leaves your hand. This may occur at any point in the cycle. For example if you move your hand upward at any velocity and stop it suddenly (momentary downward acceleration greater than $1G$) the pencil will momentarily "float." Do this with a longer and faster stroke (greater deceleration) and the pencil will not merely float close to your hand but will be hurled upward.

Next, touch your thumb to your middle finger, leaving a hollow. Now the pencil stub is like a shaft in a cylindrical bearing with excessive loose play. Vibrate your hand up and down to make the pencil "rattle" and you will appreciate the destructive effect of excessive vibrations. At the same time, however, you will appreciate that vertical vibration cannot make a loose shaft rattle if the acceleration does not at any time exceed $1G$. This value of $1G$ is the critical value for *vertical* vibrations. If the only vibrations were vertical ones, it would be relatively easy to design rubber mountings to prevent all rattling in instruments that are loose in the bearings. (In practice, instrument bearings *are* loose, because they must not be tight.)

But panel boards actually vibrate in all directions. Let us glance at what actually happens.

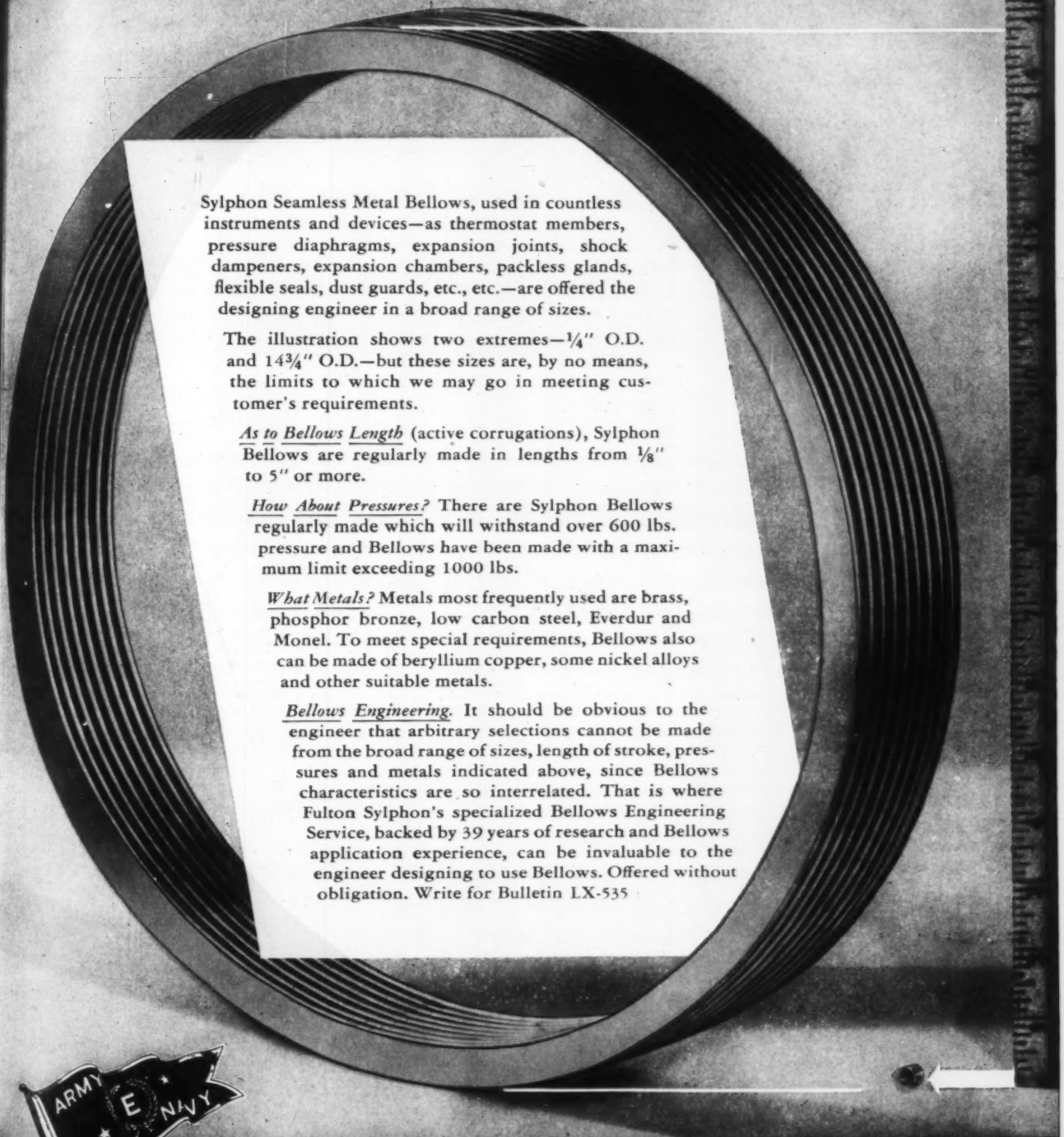
Again placing the pencil stub in your cupped hand, oscillate your hand horizontally in the direction of the pencil, faster and faster until the pencil slips. Note that it takes less than $1G$ of acceleration to make it slip. In an actual bearing with highly polished surfaces, as low an acceleration as $0.05G$ might be enough to cause slipping. Theoretically, if the friction is zero, an acceleration of just above zero G would cause slipping.

Repeat again, oscillating your hand horizontally but this time in the direction of your wrist, that is, at right angle to the pencil. See how easy it is to make the pencil roll with acceleration obviously less than $1G$. In an actual loose bearing, an acceleration just above zero value will make the shaft oscillate and, if the surfaces are highly polished, crosswise slipping will also result from relatively weak accelerations. The extent of combined rolling and slipping (due to purely horizontal vibrations of the bearing) will of course be limited by the curve which the shaft must climb. Note that when you shake the pencil hard, it climbs and hits the sides. Note also that the looser your hold, the harder it hits. That is because it hits when your hand has traveled back farther and is moving faster.

Fourth and last experiment: Oscillate your hand in any direction but always in that direction, always at the same frequency (for example 70 complete cycles per minute, like the cadence of marching), and always with the same amplitude, which condition can be met by swinging your hand in a 10" or 15" interval between two boxes. The experiment consists in varying the form of oscillation and observing the results. When your form is "trembly" or "jerkey," the pencil rolls and slips; when your form is "smooth" (like "good form" in various athletic sports), the pencil stays put; and

Concluded on page 365

How Large and How Small are Sylphon Bellows Made?



Sylphon Seamless Metal Bellows, used in countless instruments and devices—as thermostat members, pressure diaphragms, expansion joints, shock dampeners, expansion chambers, packless glands, flexible seals, dust guards, etc., etc.—are offered the designing engineer in a broad range of sizes.

The illustration shows two extremes—1/4" O.D. and 14 3/4" O.D.—but these sizes are, by no means, the limits to which we may go in meeting customer's requirements.

As to Bellows Length (active corrugations), Sylphon Bellows are regularly made in lengths from 1/8" to 5" or more.

How About Pressures? There are Sylphon Bellows regularly made which will withstand over 600 lbs. pressure and Bellows have been made with a maximum limit exceeding 1000 lbs.

What Metals? Metals most frequently used are brass, phosphor bronze, low carbon steel, Everdur and Monel. To meet special requirements, Bellows also can be made of beryllium copper, some nickel alloys and other suitable metals.

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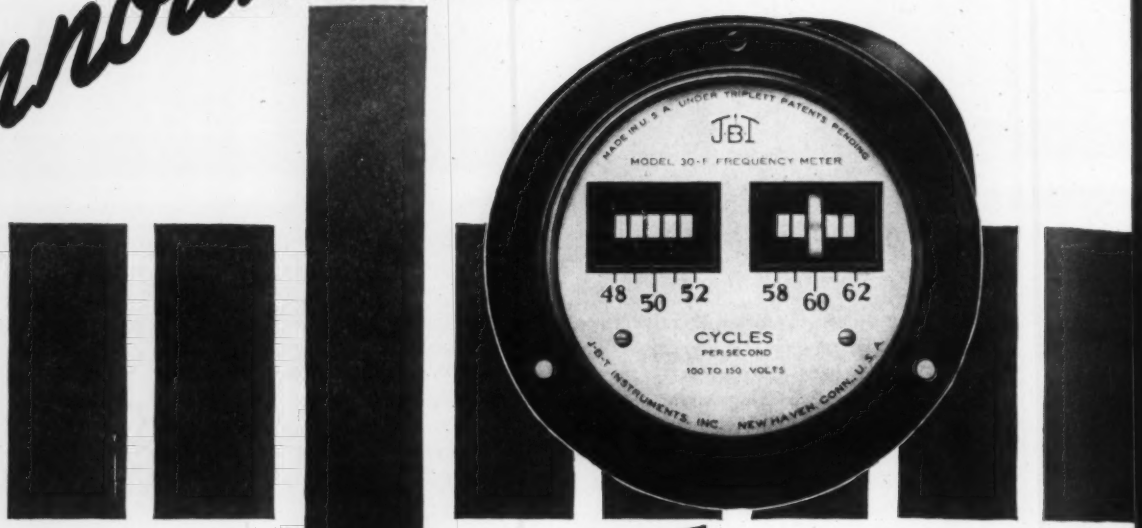

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Ordnance Production Gaging

By CAPTAIN RUSH A. BOWMAN

In charge of Pittsburgh Gage Laboratory, Ordnance Department, U. S. Army

CHAPTER IX

THE GAGE DEPARTMENT OR LABORATORY: ITS EQUIPMENT

(Continued from April issue)

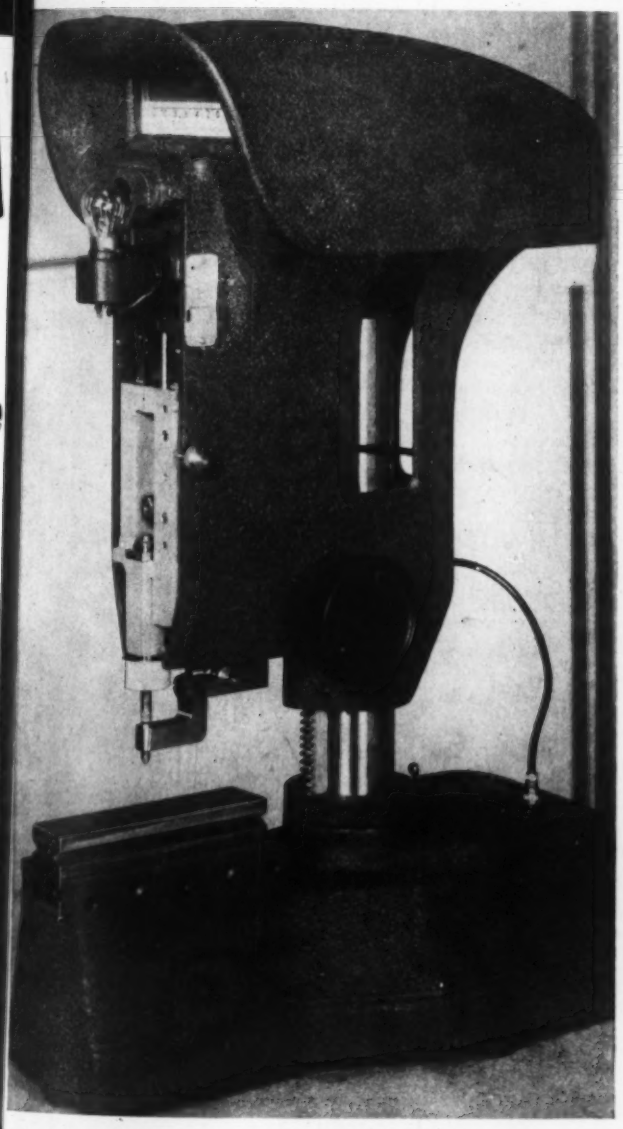
GROUP III

This group, as noted in the foregoing list, includes comarator, supermicrometer and measuring machine. In this roup, any one or a combination of these instruments can e used. The selection of an instrument should be based upon e greatest accuracy desired, the quantity of recurring easurements and the total of the inspection load.

he Comparator

The comparator (Figs. 9 to 13) is always used in conection with gage blocks. It is readily adaptable to recurring easurements, that is, where the same size must be measred a number of times, as in inspecting a dozen or so thread plug gages for a shell nose. It is a versatile instrument and may provide the greatest accuracy at the lowest price (as compared to other types of instruments in this group). However, it is not a measuring device: it must be set to some standard and the deviation therefrom measured. If a comparator only is to be used, it should be bought with two replaceable handles (serrated on one side and flat on the other), a thread attachment if necessary, and an anvil with sine block attachment. If it is to be the only instrument in this group, then, in order to obtain the best all-round accuracy, it probably would be most desirable to have each graduation represent 25 millionths.

Special Care of a Comparator—In addition to the ordinary care (protection from rust, dirt in the mechanism, etc.) steps should be taken for the periodic checking of the anvil to detect wear when it would begin to affect measurement. Wear is first apparent when the mirror finish begins to become dull. At the beginning, of course, this dullness will not represent sufficient wear to affect measurement but, after it has appeared, the anvil should be checked periodically to determine that belly in the block is not affecting the readings. The greatest portion of the work done on a comparator is cylindrical (see Fig. 13), and in almost all cases it is a



ig. 9. A mechanical type comparator reading directly to 0.00005", as manufactured by Sheffield Corp. (Cover removed to expose part of mechanism.) Note that an attachment, below usual anvil, is in place for measurement of threads.

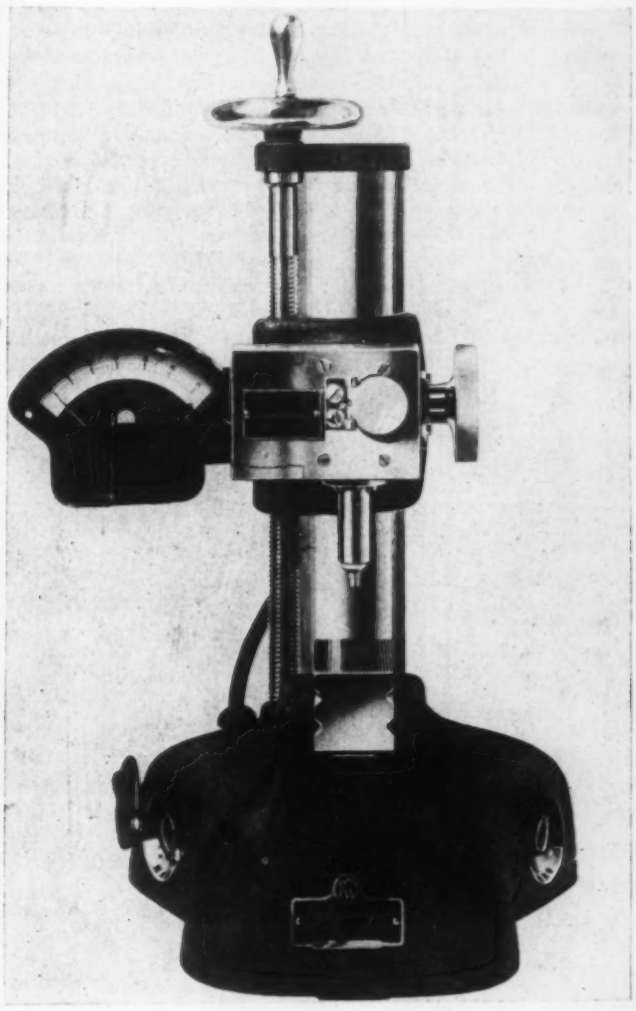


Fig. 10. An electrical type comparator reading directly to 0.00002" as manufactured by Pratt & Whitney Co. incorporating General Electric Co.'s measuring head and indicator.

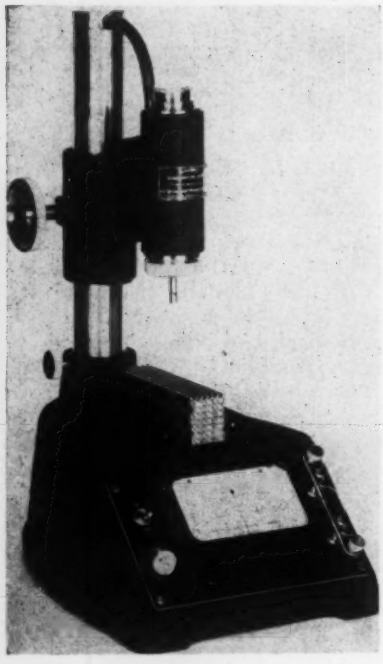


Fig. 11. (Metron Instruments Co.)

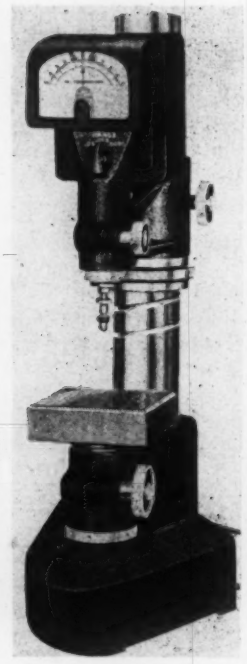


Fig. 12. (Televiso Products, Inc.)

Multi-range electric comparators. These new devices (both announced in 1943) have selector knobs whereby operator chooses magnification.

matter of rolling a plug underneath the anvil from front to rear. This will normally give a fairly symmetrical wear in the form of a valley directly under the gaging point and normal to the length of the block. It is inspected with a standard roll 1″ or more in length and 0.200″ to 0.500″ in diameter by taking a reading rolling the roll under the anvil from front to rear and then using the same roll, rolling it from side to side. If the anvil is not worn, the readings should be the same. If, however, wear has taken place, the valley in the anvil will be breeched by the roll in rolling it from side to side, and the same roll will measure larger in this position.

The two extra anvils used in connection with this instrument should be used for interlapping in order to maintain all the true surfaces. By interlapping of three surfaces, im-

Fig. 13. Sheffield Corp.'s "Visual Comparator" being used to inspect plain plug gages. Note that plug gage is being "rolled" under anvil as prescribed in Chapter II.

perfections in all the anvils are compensated for and the result is three flat anvils. An additional advantage of extra anvils lies in the fact that there always is a replacement in case one should become marred or scratched.

Another method for checking anvils is by "blueing them in" with another anvil which is known to be true. This method is accurate but it usually will be found that considerable experience is required before this method can be used effectively. It is, however, commonly used for a quick check during the lapping process.

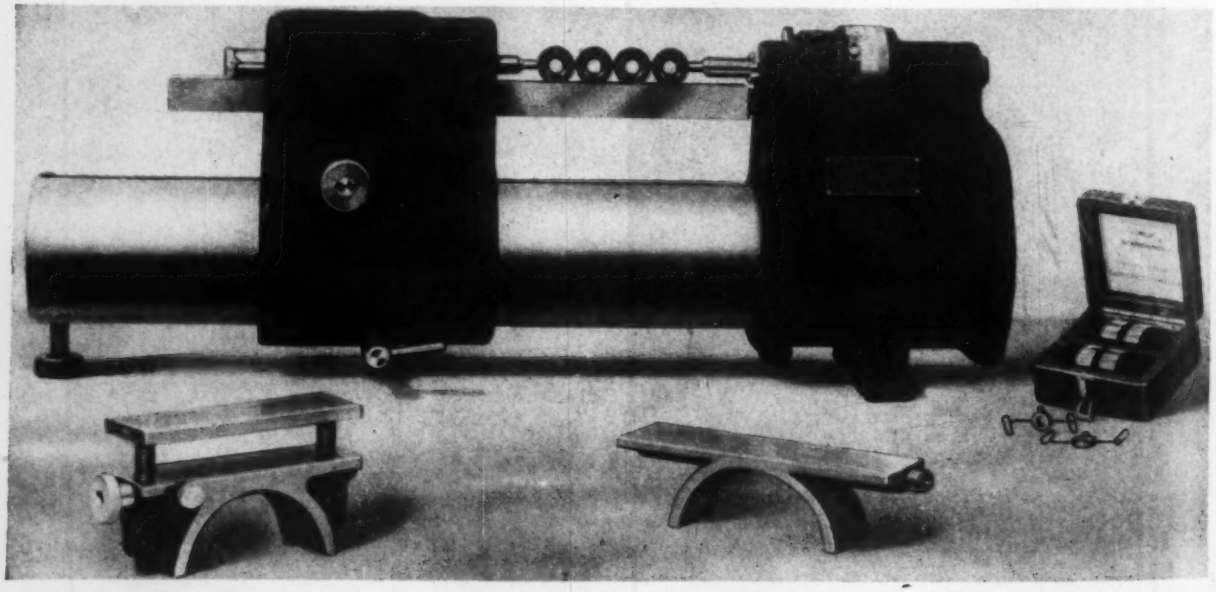


Fig. 14. A supermicrometer as manufactured by Pratt & Whitney Co., shown complete with plain table, elevating table, one-inch standards and wire holders. The operation being shown is setting to 4″ by means of standard one-inch rolls. It may of course be set by means of gage blocks but the rolls come with the machine and therefore are always available.

he Supermicrometer

The supermicrometer, Fig. 14, is an instrument which has njoyed relatively wide usage. It has a range of 8" and is ead to 0.0001" on the vernier scale. It obtains its accuracy substituting a constant predetermined pressure for feel," the pressure being indicated by a pointer-and-scale the specially-designed tailstock. It is set by standards any even inch and will read anywhere within an inch irectly to size. It is one of the most easily used precision achines—requiring a minimum of resetting. Where measrements of a particular size are not recurring, it probably the fastest inspection instrument of the ten-thousandths ccuracy class.

Special Care of the Supermicrometer—Outside of the rdinary care with which an instrument of this type should handled, a routine should be prescribed in order that he anvils between which measurements are made are hecked and lapped periodically. Necessity for lapping may e shown as follows: Firstly, by putting a precision ball etween the anvils, moving it around to different positions etween the faces, and noting whether any differences in eading occur. Secondly, by placing a standard roll of 0.100" r 0.200" diameter between the anvils in a horizontal posiion and moving it vertically and then changing it to a verical position and moving it horizontally: if the anvils are at and parallel, there should be no movement in the indiator. If variations do occur, conditions of belly or taper ill be shown by these tests and the anvils should be reapped. They are relapped by means of a lapping block havng faces that are flat and parallel. The block is moved etween the anvils under slight pressure—not in any single irection or pattern, but with the greatest possible randomess, in order that the wear be evenly distributed over the ntire surface of this block. When the anvils have been roperly relapped, the ball and roll tests should not indicate onditions of belly or taper between the anvils.

he Measuring Machine

The measuring machine, Fig. 15, is unique in that it prodes its own standard in the form of a master bar gradated at 1" intervals*—these reference marks being fine airlines viewed through the microscope in the measuring ead. These graduations are transferred from the P&W master bar calibrated at the National Bureau of Standards.

*or 25-mm. intervals in the Metric System measuring machines.

This does not mean, however, that the measuring machine can be used as a measuring instrument instead of gage blocks, since it is used for external measurements only. It is made in sizes from 12" to 80", the most popular being 48". It measures to an accuracy of 0.00001" using the vernier. "Feel" is eliminated by an arrangement whereby the measuring pressure is controlled and exactly *reproducible*, being indicated on a milliammeter whose scale has a magnification (in terms of lengths) of 5000×. Such an instrument is a desirable acquisition in a laboratory where measurements of lengths exceeding 12" or 15" must be made to an accuracy of 0.00005" per inch of length and must be made as often as, say, four times a week. Because of its price and the fact that lengths of 12" to 15" will cover most of the measurements (the long gage blocks and indicators taking care of special cases) this instrument is not usually found in a laboratory where first cost of equipment is the governing consideration.

Special Care of the Measuring Machine—The measuring machine requires essentially the same care as the supermicrometer in regards to its anvils. It will be found that in the lapping of these anvils, the sensitivity of the instrument will require more nearly perfect surfaces and, therefore more time may be necessary to lap them accurately. The surfaces of the buttons on the master bar, which bear the reference hairlines, are delicate. They should *never* be cleaned except with a light oil applied by means of a soft camel's hair brush. When the head has been set, the buttons should be recoated with a heavier oil and the protecting cover replaced.

Group IV

Micrometers.

Hand micrometers in the Gage Laboratory have essentially three purposes: (1) Routine inspection where tolerances are 0.001" or more; (2) Quick checks where ten thousandths may be approximated; (3) Actual inspection where comparators, measuring machines, indicators, etc., are not feasible due to the size or shape of the gage as, for instance, a locating pin in a complicated fixture gage which is too heavy to set on a supermicrometer. In this latter type of inspection, if measurement is desired accurately to 0.0001", "feel" becomes an important factor. Suppose the pin just spoken about has a tolerance 0.1250" –0.0002". In this case, the reading of the micrometer should not be taken for the size. The micrometers should be set to the inspector's feel

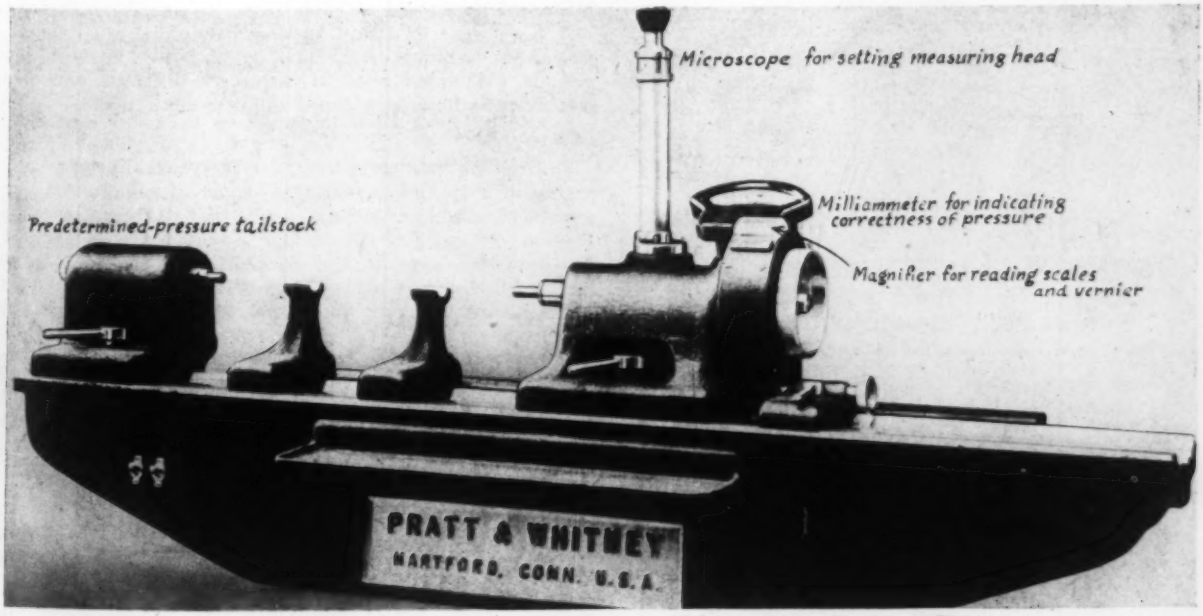
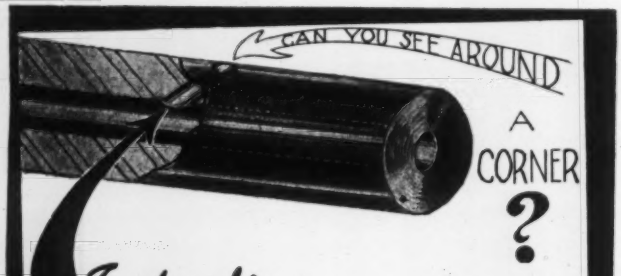

Microscope for setting measuring head
Predetermined-pressure tailstock
Milliammeter for indicating correctness of pressure
Magnifier for reading scales and vernier
PRATT & WHITNEY
HARTFORD, CONN. U.S.A.

Fig. 15. A measuring machine as manufactured by Pratt & Whitney, shown with supports. An elevating table similar to that in Fig. 14 is also furnished. The General Electric measuring head and indicator are similar to those shown in Fig. 10.



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over a 0.125″ gage block. Micrometers should then be locked and checked again for size. Gage blocks should be moved back and forth between the anvils to ascertain the feel of the micrometers. A feel no lighter than this should not be experienced when the pin is introduced between the anvils. Micrometers should then be unlocked and set in the same manner to blocks equaling 0.1252″ and the same procedure followed through. This will determine that the pin is definitely between the two sizes.

Hand External Micrometers to 3″.

Hand micrometers to 3″ should definitely be included in the equipment of the Gage Laboratory. (See Fig. 16.) External micrometers above 3″ are not normally needed in the Gage Laboratory. Sizes above this can, in almost every case

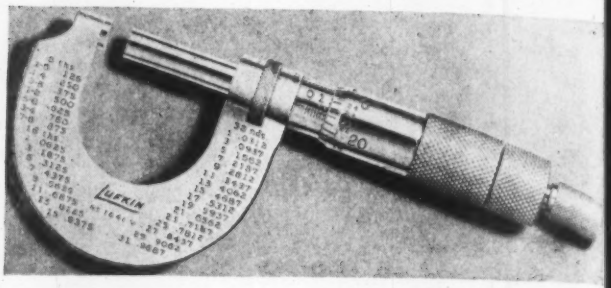

Fig. 16. 0-1″ Micrometer with 0.0001″ vernier. (Lufkin Co.)

be measured accurately with some other method. The micrometers to 3″ should, however, be equipped with vernier for measuring ten thousandths. It would be found that an experienced inspector having a set of hand micrometers with which he is familiar can measure accurately in ten thousandths up to about 3″. Above 3″ the micrometer frame is rather susceptible to expansion due to body heat transmitted through the hand.

Special Care of External Micrometers—The most important condition to watch for in micrometers is the parallelism of the anvils. Without this, micrometers cannot be depended upon to give an accurate reading. They should be checked periodically for parallelism by placing a check block on one anvil and a roll between the other end of the gage block and the other anvil. If the anvils are parallel, the roll can be moved in any position without particularly tightening or loosening the feel. The anvils on a 0-1″ micrometer may be relapped in the gage laboratory with small lapping blocks having parallel sides in much the same manner as has been described for supermicrometers and measuring machines. Lapping of anvils of micrometers above 1″ should not be attempted without necessary fixtures and special equipment which are needed for this kind of job.

Internal Micrometers

Internal micrometers are of two types: The pin type as shown in Fig. 17 in which a micrometer spindle and gaging point are attached to the end of a pin of known length, and the expanding plug type which is not a necessity and will be discussed later in the chapter. The pin type internal micrometer is the simplest type of instrument for the measurement of internal diameters and is quite satisfactory

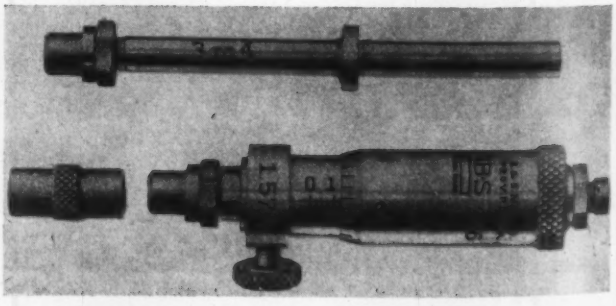

Fig. 17. Inside micrometer, pin type. (Brown & Sharpe)

en properly used. The pin type, of course, should not be d for "tenth" measurements except by mastering and ling against a known dimension as set up by gage blocks, permicrometer, measuring machine, etc., as described at beginning of the discussion of Group IV.

Special Care of Internal Micrometers—Internal microm- rs of both the pin and expanding plug type are quite nerable to dirt and should be cleaned periodically. Dirt tween the pin and the micrometer spindle, which is a mmon occurrence, will invariably result in error in cases ere the micrometer is being read directly.

pth Micrometers

Depth micrometers as shown in Fig. 18 follow essentially e three purposes for hand micrometers. In all laboratories

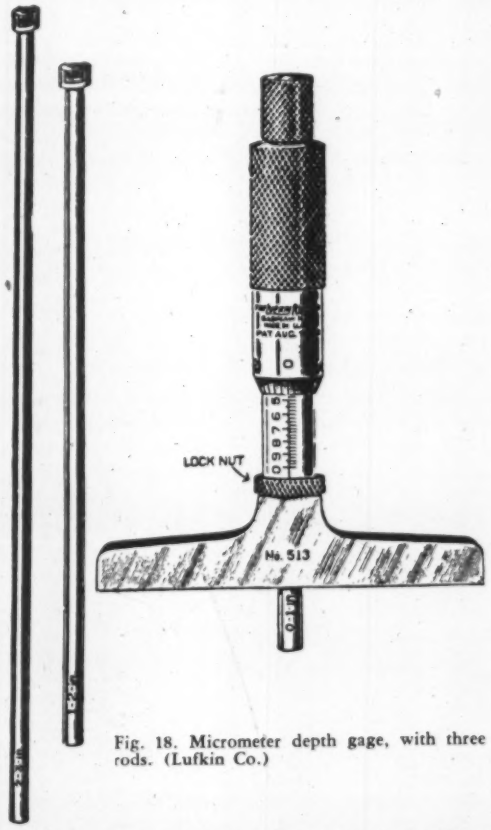

Fig. 18. Micrometer depth gage, with three rods. (Lufkin Co.)

here a minimum of equipment is required, depth microm- ters should be provided to 6". Depths beyond the limit of his instrument will normally require special setups, etc.

Special Care of Depth Micrometers—The flat anvil on a epth micrometer must be lapped periodically and great are should be taken that the plane of this anvil is normal o the axis of the spindle and pin and parallel to the face f the pin. Frequent relapping will not be necessary, except n cases where the same or similar gages are constantly re- hecked, since this repeated use would localize wear and ause inaccuracies in measurements.

Group V

The Surface Plate

If one surface plate only is to be used, its size will be etermined, of course, by the gages to be inspected. It hould be noted that the longest gages which would be hecked on a surface plate should, when placed diagonally cross the plate, leave at least 6" at the corners for work- ng purposes.

Iron surface plates of the machine shop variety are made ither plain ground or scraped. The surface plate shown in Fig. 19 is a scraped plate which has been ground flat and hen portions of the surface scraped away with a sharp tool ntil only a certain percentage of the original surface is eft unchanged. These portions of the original surface which remain are called "flats" or "spots" and, in a well scraped

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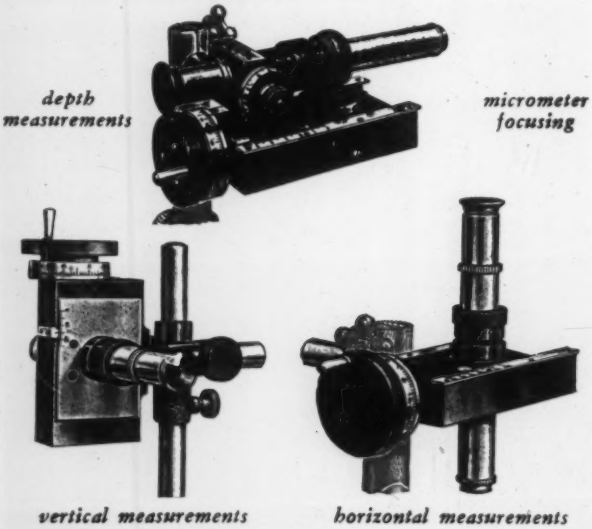

vertical measurements *horizontal measurements*

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Fig. 19. Scraped iron surface plate. (Swanson Tool Co.)

surface plate, may number as high as 25 to 30 per square inch of surface. These plates are scraped in order that highly finished surfaces such as gage blocks, surface gage bases, etc., will not wring to the surface of the plate and restrict the movement of the objects on the plate. Scraped surface plates are normally inspected by blueing-in against another surface plate of known accuracy.

Glass surface plates have lately received considerable publicity. One advantage, of course, is the reduction in the use of critical materials. Another is the reduction in time of manufacture since seasoning is not necessary as it still is for iron to obtain the requisite stability. The Pittsburgh Ordnance District Gage Laboratory experimented with the use of glass for surface plates early in 1941.* Three pieces of 1¼" plate glass having fair shadow patterns were interlapped, using chalk dust and water or Dutch Cleanser and water as a lapping compound. It was found that the glass lapped readily and that the resultant surface was remarkably flat: it required the use of optical flats to detect "waves" when the plates were properly supported. These plates were mounted in a wooden box and supported in a

*The idea of using glass for this purpose had been investigated previously by the engineers of the Pittsburgh Equitable Meter Co., Pittsburgh, Penna., who had used plate glass in much the same manner as a layout table for complicated template gages, etc. In these cases, the template was wrung to the glass.

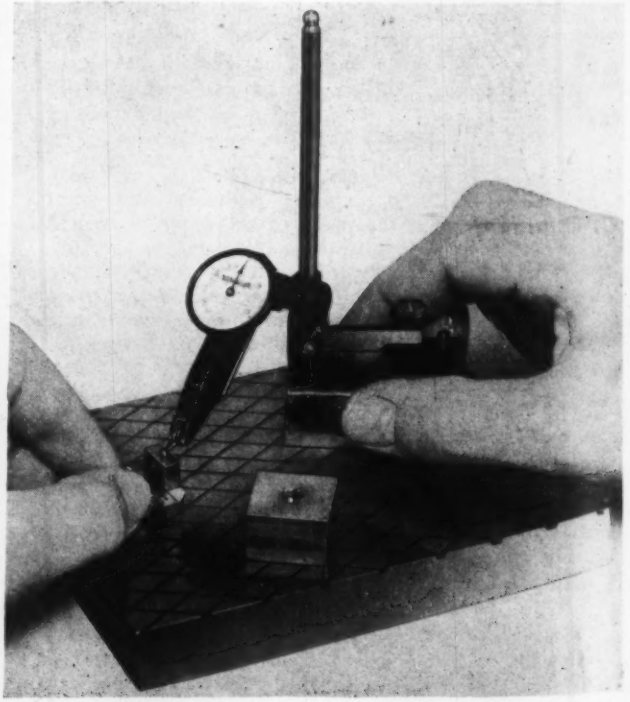

Fig. 20. Dial test indicator (Federal Products Corp.) mounted on surface gage, comparing height of gage with gage block.

caulking compound to distribute the load evenly. These glass plates were most satisfactory in that they had good life, and the scratches would break into the surface but did not affect the flatness of the plate (as is the case when an iron plate is scratched and the displaced metal is pushed into the side, leaving a ridge in the plate). The most notable disadvantage of the glass surface plate was the tendency for objects having highly finished surfaces to wring to the plate. The commercial designs now on the market have by one method or another eliminated this difficulty.

Special care of Surface Plates—Iron surface plates are readily scratched and, when scratched, the burr which is raised will invariably result in inaccurate measurements. Personnel should be well trained to guard against the inaccuracies which creep in on this account. When burrs do occur, they should be stoned off with a hard Arkansas stone by someone fairly familiar with both the use of the surface plate and the use of such a stone. Glass surface plates do not lend themselves to heavy work, i.e., to concentrated loads in excess of the average run of work in the Gage Laboratory which this chapter has in view.

Group VI

Indicators

Indicators are used for comparison purposes (see Fig. 20) in much the same manner as the comparators described in Group III, but where less accurate measurements are required. Indicators are used in connection with some other

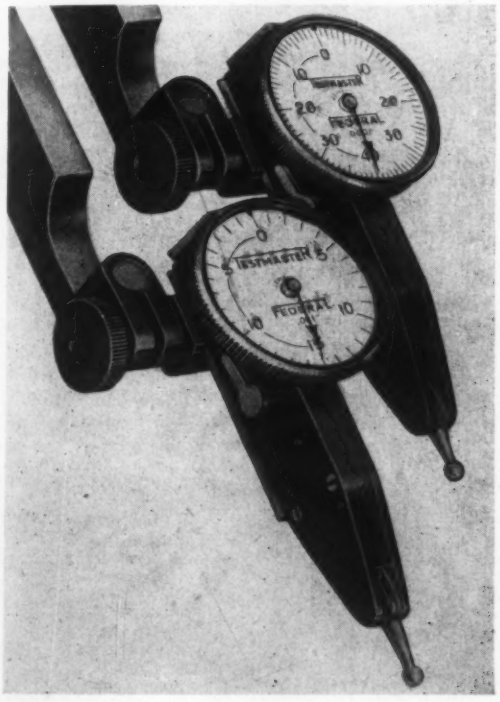

Fig. 21. Dial indicators (0.001" and 0.0001") with "universal" shank. (Federal Products Corp.)

device, such as surface gages or height gages. They are essential in almost all surface plate work; also in determining concentricity or eccentricity of cylindrical objects rotated on centers. The particular indicator to be used in a set-up is determined by the accuracy required in measurement. In Fig. 21 are shown two dial test indicators, one having graduations in ten thousands, and one having graduations in thousands. This particular type of design (first brought out by the L. S. Starrett Co. as the "Last Word" indicator) is excellent for use in the Gage Laboratory since it makes possible inspection of surfaces which are difficult

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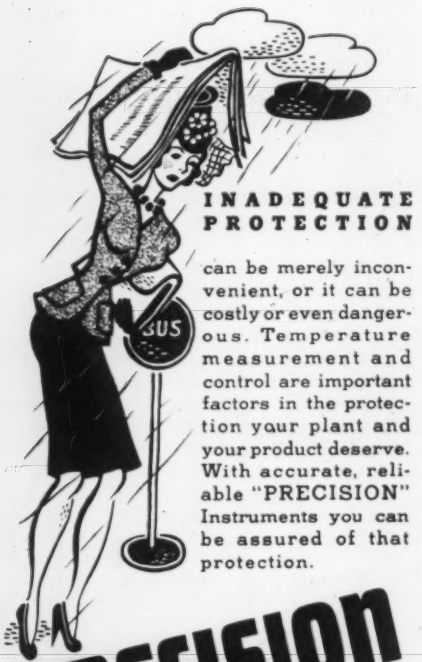

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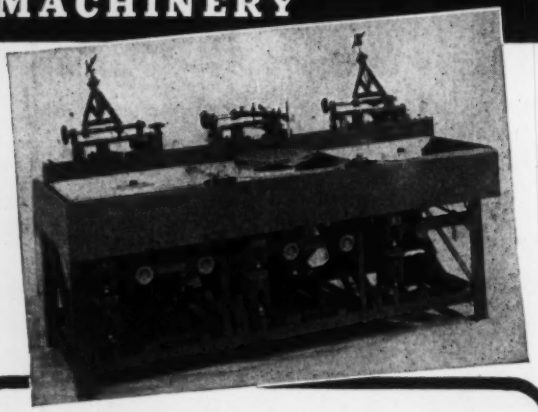

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to reach by reason of their location in a complicated ga or fixture.

Each indicator should be assigned to one person (or one on each shift) in order that he may learn its idiosy crasies. Some indicators have a light feel, others a fair heavy feel. A particular indicator may have a ball poi which the inspector desires to have fairly loose on the spi dle so that a jolt will cause the ball point to slip rath than injuring the delicate mechanism. In such an indicat care must be taken that the point is not moved in ordina set-ups. Furthermore, the accuracy of an indicator vari throughout its entire dial reading range—not necessari because of intrinsic inaccuracies but chiefly because errors due to conditions of use. Therefore, a practic method for determining what portion of the dial range most accurate is continued use and experience with a pa ticular indicator. An inspector will discover that "his ind cator" has a particular "personality" and will use it accor ingly, taking into consideration its peculiarities.

Special Care of the Dial Indicator—Most frequent tro bles with dial indicators arise from dirt in the mechanis and from slippage of the needle on its shaft. This first dif culty can be recognized by a sluggishness of the needle its travel or by the inability to make the indicator repeat particular reading. Slippage of the needle can be recogniz by the failure of the indicator to return consistently to ze after the point is moved and released. In either case, t dial indicator should be disassembled by a person speciall experienced in the repair of dial indicators, thorough cleaned with a good solvent, and properly reassembl (Even an expert repairer of precision instruments requir special experience with dial indicators.)

Oil should never be used on any indicator. It picks u dust and dirt and transfers it to the mechanism. The bea ings in indicators are made in such a manner that they wi function without oil and their failure to function is usuall due to some mechanical difficulty other than in the bearing —a bent rack, a bent spindle, or some other difficulty of thi nature.

Group VII

Surface Gage and Vernier Height Gage

The surface gage, Fig. 22, and vernier height gage, Fig 23, are used for purposes of layout and also to support indi cators where indicators are required in surface plate work Either of these two instruments may be used and, there fore, one only would be required in a minimum-equipmen laboratory. In case the height gage is used, a one thou

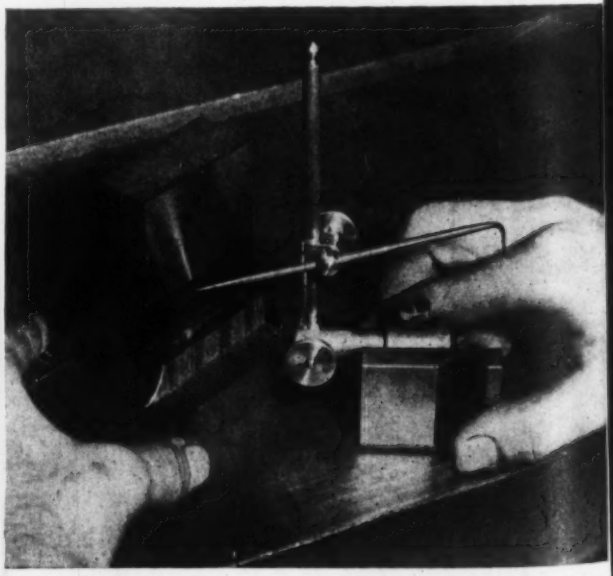
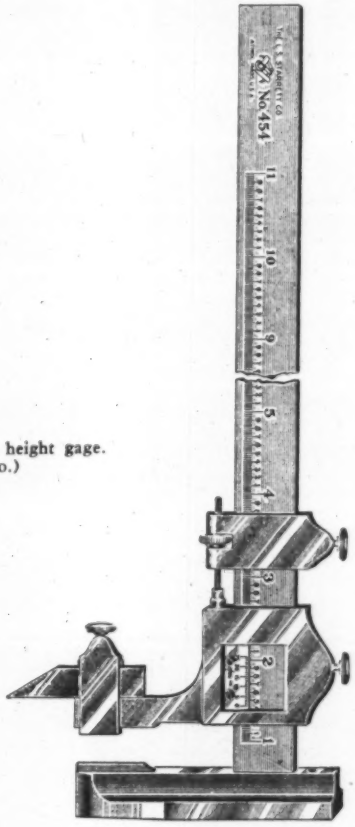


Fig. 22. Surface gage being used (on a surface plate) in layout work at the Frankford Arsenal. *(U. S. Army photograph)*

ndth indicator might be eliminated as the scale may be d to thousandths with the aid of the vernier. The height ge, however, is not so flexible as far as set-ups are con- rned since the position of the indicator is rather limited th respect to the base. If a surface gage is used, it will seen that the spindle may be placed at almost any angle.



g. 23. Vernier height gage. L. S. Starrett Co.)

The vernier height gage, it should be noted, may be used as a measuring instrument where measurement to thousandths only is required.

Special Care of the Surface Gage—The base of the surface gage is its most vulnerable point because of the possibility of scratches, burrs, etc. A gage in use should always be wiped clean before setting on a surface plate and should be well examined before it is used in a set-up. When scratches do occur, they should be lapped or stoned off* in order not to give inaccurate readings or scratch the surfaces with which they come in contact.

Special Care of the Vernier Height Gage—Vernier height gages, in addition to the care of the base (same as that of surface gage) should be protected against dirt on the scale and slide. Furthermore, since wear occurs on the base, the surface gage must be recalibrated from time to time in order that the readings will be reliable. This is a rather simple process involving merely the movement of the vernier scale. Expert skill is not required. It should be the responsibility of the inspector in whose care the instrument is placed that the vernier scale does read properly.

To be continued

*See care of surface plate, under Group V, for use of Arkansas stone and necessity of extreme care.

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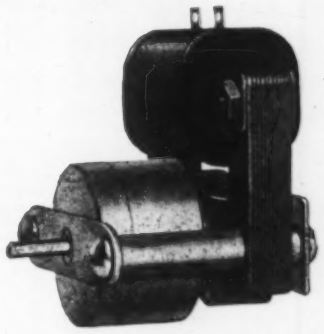

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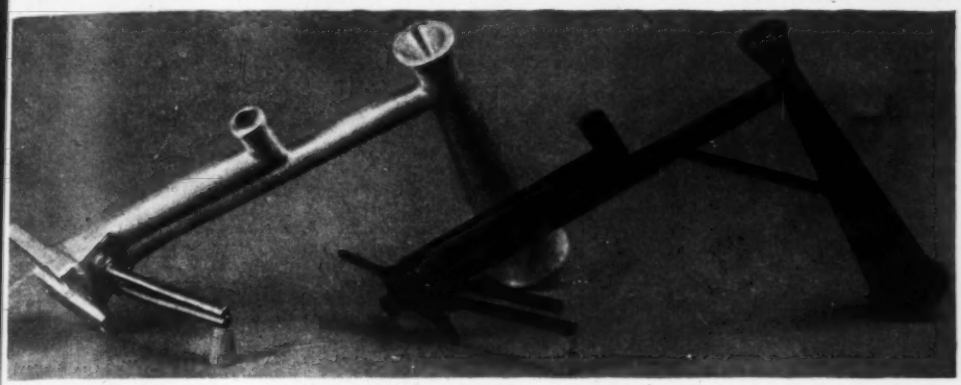
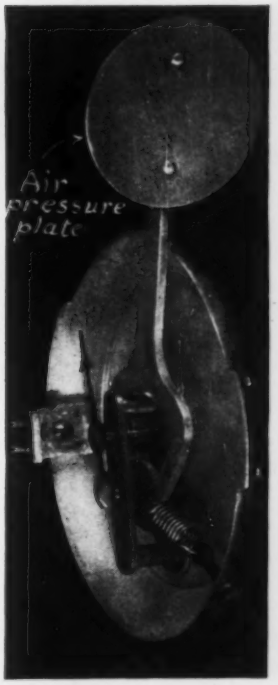
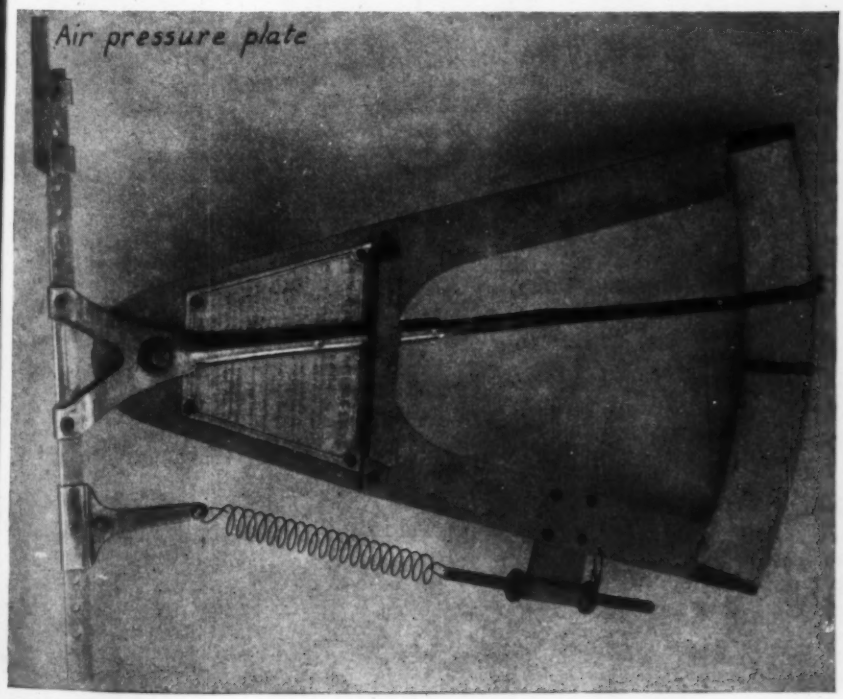




Old and Odd Aircraft Instruments

(Second Instalment)

FIRST instalment appeared just a year ago, comprised a variety. This time we show only three, in close-ups, all pertaining to air speed. In World War I, air speeds were about 60 to 120 m.p.h. and the Venturi throats combined with Pitot tubes (above) were useful in boosting the Pitot differentials. As for the two pressure-plate type air speed indicators (right and bottom) don't laugh: the physical principle was okay and the trouble was with placing them close enough to read, yet beyond the prop wash.—M.F.B.

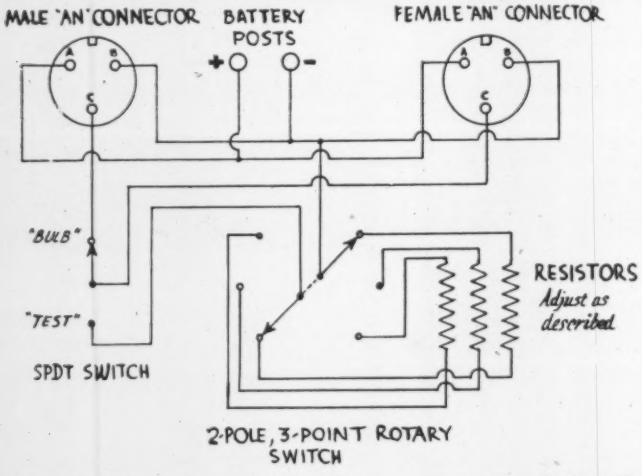


Thermometer Installation Tester

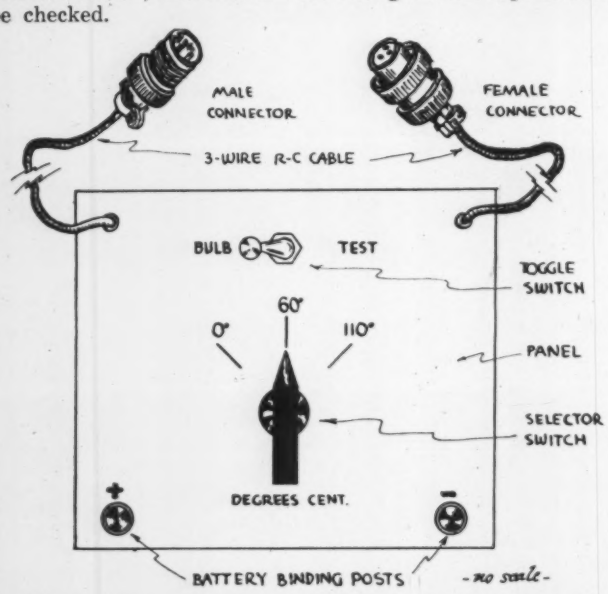
By M. J. WIGGINS
Instrument Instructor (other data censored).

THIS little unit was built to permit rapid checks on resistance thermometer installations. Using it as a trouble-shooting device, the seat of the trouble can be found in a matter of minutes. Instruments may also be checked on the workbench with this test box.

To test a faulty installation, the female Cannon plug is connected to the thermometer under question and the male Cannon connector is plugged into the instrument cable



plug. With this hook-up the instrument is supplied with battery through the test box from the instrument cable. The small toggle switch is thrown to "Test." This disconnects the thermometer bulb from the instrument and connects one of three resistors in its place. One of these resistors is calibrated to give a reading of 0°C., one to read 60°C., the other to read 110°C. (These are used for thermometers with 60° balance point. Any range desired can be substituted.) By selecting the desired resistor with the selector switch, the instrument readings at these points may be checked.



If the instrument does not read correctly when checked as described, the trouble lies in either the battery leads or the instrument itself. If a voltmeter is handy the voltage can be read at the two binding posts on the panel. If no voltmeter is available, by disconnecting the male plug from the instrument cable and connecting the binding posts directly to battery, the instrument can be checked again. If now the readings are correct, the trouble is in the battery wiring.

If the battery leads are OK and the instrument reads incorrectly with the test box, the instrument is defective.

If the instrument reads correctly according to the test box, throw the toggle switch to "Bulb." The thermometer should now read approximately the temperature of the bulb. If this reading is obviously off or the pointer goes hard over, there is trouble in the thermometer bulb or its leads.

On the workbench an instrument can be checked by plugging it into the female connector and attaching a shop battery to the two binding posts. This way a defective instrument will be caught before installing.

The connectors used are standard AN type with cable adapters. Three-wire rubber covered leads are used and can be any desired length. The selector switch is a rotary three-position two-contact radio type. The three resistors should be wound after the rest of the unit is complete. By hooking up an instrument which is known to be correct, each resistor can be adjusted by connecting into the circuit and the amount of wire varied until the desired reading is obtained. Manganin wire should be used because of its low temperature coefficient. Inasmuch as most thermometers operate on 14 or 28 volts and the normal battery voltage, without engines running, is 12 or 24 volts, the values of these resistors will not be the same as the values given in the bulb tables, except at the balance point.

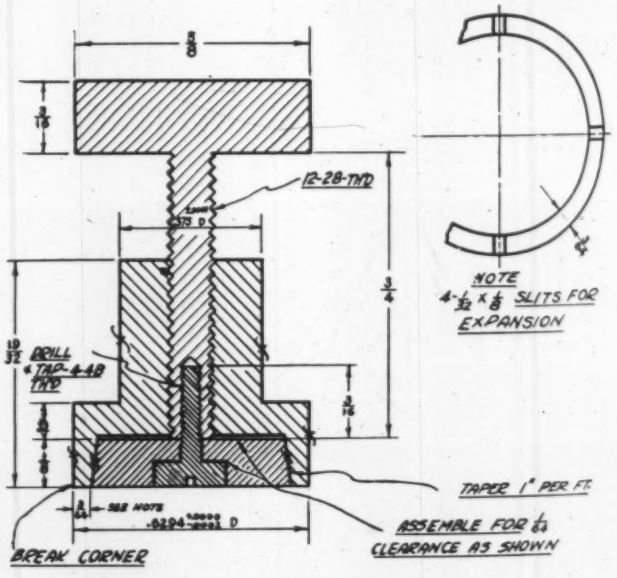
Rotor Centering Plug for Directional Gyro

By ROLAND M. TORGERSON
Head of Dep't of Gyroscopic Instruments
Naval Air Technical Training Center, Chicago, Illinois

AN important step in the overhaul of the directional gyro is centralizing the rotor in the gimbal ring. Since the tolerances are extremely close, it is necessary to have a plug which will fit the bearing recesses of all gimbal rings. In many cases the standard plug is found to be too tight or too loose and indicating the surface of the recess is generally unsatisfactory: it may be scratched or burnished.

The expanding centralizing plug shown in the drawing is easily made on a lathe. The plug has been used in the shop several weeks and has proved to be accurate and easy to use. Some valuable features of the plug are: (1) The dial indicator slides over the 0.375" diameter of the plug with ease. (2) The plug can be extracted from the recess by turning the screw clockwise, which eliminates the use of pliers or other means of removing the plug that may bend or mar the surface. (3) It can be tightened in the recess by turning the screw counter-clockwise.

Since it is desirable to make the plugs in pairs so one can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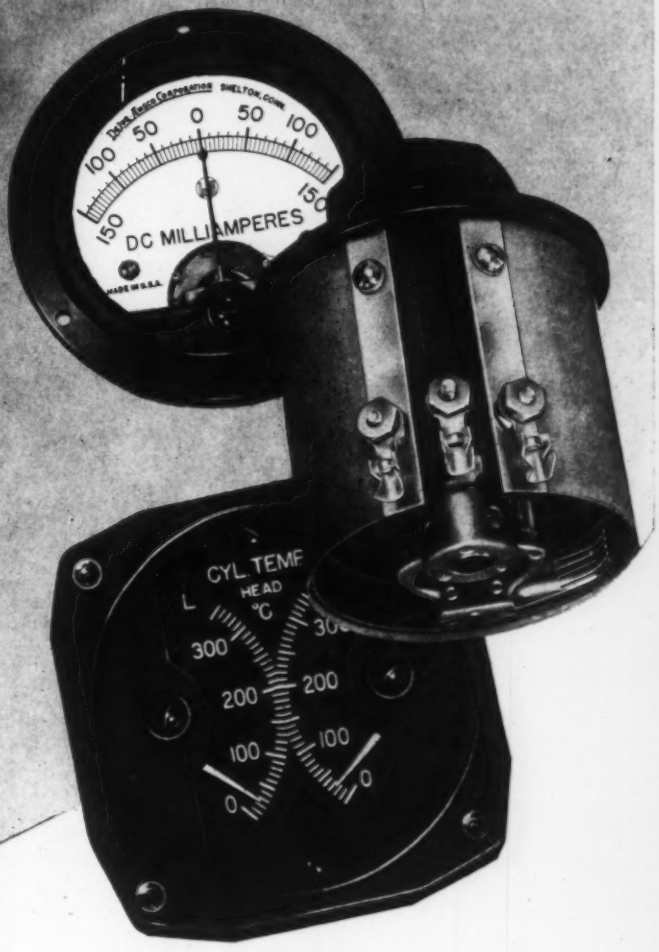

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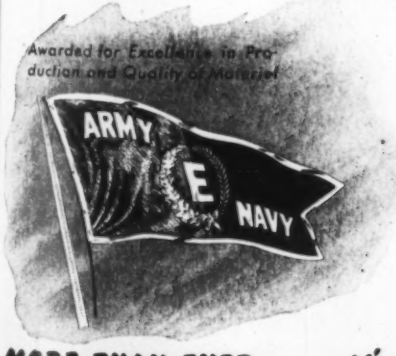

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Electrolytic and oil-filled capacitors in this plug-in construction. Units firmly held in standard plug-in sockets. Where subjected to severe vibration, mounting lugs are available.

● There's something prophetic about this Aerovox capacitor. The plug-in feature denotes ready check-up and replacement. It signifies continuous, gruelling, accelerated-wear service that wears out the best capacitors in months instead of years. Just as the demountable-rim wheel marked the transition from Sunday motoring to everyday essential transportation, so this plug-in capacitor spells infinitely expanded usage of *radio* technique, components, manpower.

Our first job is to win the war. Aerovox is now concentrated on just that. And while tens of thousands of radio men are gaining invaluable training and experience and, indeed, compressing decades into years, so we at Aerovox are laying the foundation for vastly expanded radio and electronic opportunities in the coming peace. Thus "The shape of things to come."

● **Write on your business stationery for our latest catalog. And don't hesitate to submit your capacitance problems and requirements.**

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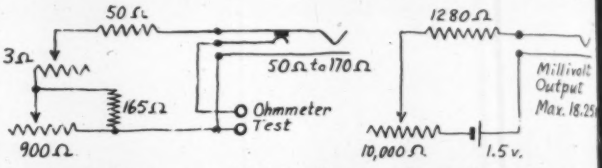
be placed in each end of the gimbal ring, use a medium fine India stone to grind the 0.375" diameter in the la to a tolerance of ±0.0001".

Electric Thermometer Tester

By Pfc. JOHN G. NYEHOLT, Instrument Specialist, 14th Ferrying Squadron, Palm Springs Air Base, Calif.

TROUBLE-SHOOTING on the field without adequ equipment presents difficulties. To speed up locat trouble in resistance type aircraft temperature indicato a variable-resistance hookup, as shown, mounted in a ha made box, and made mostly of old radio parts, proved u ful. It must be borne in mind that this outfit is not inten to be used to check calibration, but merely to determ whether the malfunctioning of the thermometer on the pla is in the instrument itself, in the connecting leads, or the resistance bulb.

The component parts consist of a 900-ohm variable sistance, shunted across a 165-ohm fixed resistance (t hookup makes possible a more sensitive resistance var tion), and a 50-ohm fixed resistance in series with a 3-oh variable, hooked up as shown. The two terminals are f hooking in an ohmmeter if desired, whereby the resistan can be set to approximate any desired reading (by referri to the proper resistance-temperature table for the bu under test) and a fairly close calibration check can be mad The ohmmeter is disconnected upon insertion of the pl



in the jack, to prevent interference from the voltage dr in the ohmmeter while conducting the test. With the 3-oh variable, it is possible to adjust the resistance in quite sma increments. This would be advantageous if an identic instrument to the one under test were available, inasmu as the resistance could be adjusted to any given indicati and compared with the reading of the instrument bei tested.

The connecting plug is attached to two leads about tw feet long with male Cannon plug fittings soldered on fo convenience in making connections at the bulb end. Tw pair of female Cannon plug connections are joined togethe with short leads to facilitate making connections direct to the instrument, when desired.

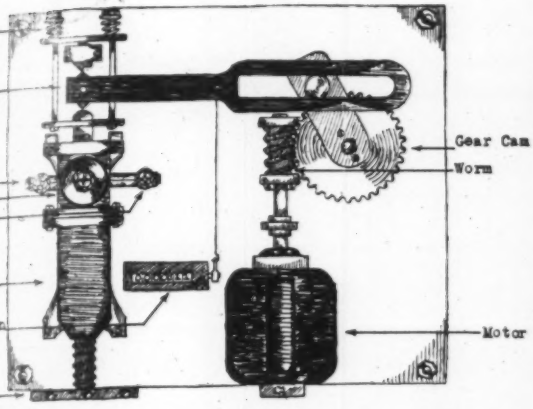
Mounted in the same box, for testing cylinder head tem perature gages, is a single flash-light cell in series with a old radio rheostat of 10,000 ohms, plus 1280 ohms fixe resistance, which can be made up of any combination o resistors available. This will give a maximum millivolt out put of about 18.25 millivolts, or sufficient for full scale de flection (350°C.) of the instrument. The dial on the rheo stat can be marked off in increments of approximately 50°C but, again, this tester was not built for making calibration checks, but merely to make a quick check for malfunctioning and/or *approximate* accuracy, when more elaborate equipment is not available.

Seasoning Bourdon Tube Instruments

By PAUL S. WHITE
Inspector (name of plant deleted), La Crosse, Wis.

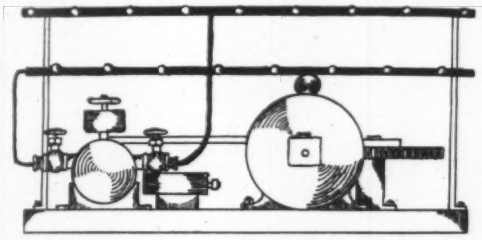
THE seasoning test, as applied to aircraft instruments as well as to different industrial types, is perhaps one of the greatest benefactors in ascertaining the actual life-time performance and reliability of pressure type gages.

Through the medium of seasoning, the peak performance may be determined before shipping new type instruments, as well as meeting the type test requirements of the Army and Navy on all aircraft Bourdon tube types. On new instruments this test is most beneficial as it shows the weak



nts, the peak load and makes it possible to check which the various parts may break down most frequently in rvice, thereby providing the equivalent of a chart for re parts, so essential at the present time for maintain- aircraft instruments in the field.

There are several methods for handling the seasoning t, but perhaps the simplest and most accurate of these as illustrated in Fig. 1. Utilizing an electric motor, cali- ting pressure pump and revolution counter, a reliable soner may be constructed at low cost, which enables the



nufacturer as well as the inspector to season an instru- nt any desired number of cycles while busying himself th something else, thus providing for an accurate check be maintained mechanically.

The testing device is connected in conjunction with a man- old, illustrated in Fig. 2, so constructed as to handle a antity of instruments at one time, rather than single ges, thus permitting a reasonable percentage check to be intained at all times.

AIRCRAFT INSTRUMENT GUILD

INTERNATIONAL HEADQUARTERS

812 N. DELAWARE PLACE
TULSA, OKLAHOMA

The following articles (to the bottom of Page 362) have been contributed by the Aircraft Instrument Guild. For further information on any of the subjects discussed, write to the Guild at the above address.

A.I.G. News Column

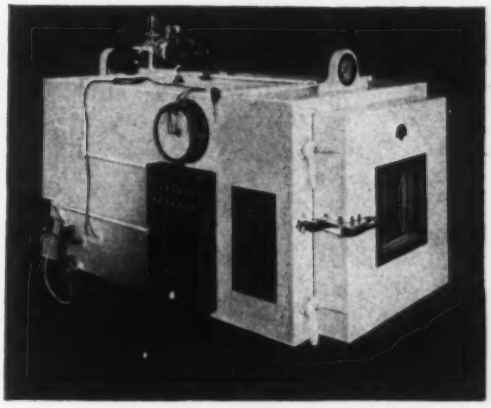
By A. J. PFISTER, Jr., Secretary

We are adding new members every day, some as far away as frica. Many of these new members have requested charters for cal chapters and the necessary information and help is now ing assembled for their benefit.

Mr. A. F. Cone of Omaha, Nebraska, has done a fine job and s been approved for Chapter No. 2.

Among others requesting information as to the proper procedure r starting a local chapter are: J. A. Burns, Chicago, Illinois; ck H. Jensen, San Bruno, California; H. N. Harrington, Wichita, ansas; H. A. Cole, Atlanta, Georgia; M. K. Olson, Ogden, Utah;

★ ★



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Radio and Electrical equipment is being tested in Tenney units by leaders throughout the country. Uncle Sam's Inspectors are passing it after exacting tests with words of highest praise to the Electrical Engineers—

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Tenney units reproduce any atmospheric condition from the ground to Stratosphere. Tenney Engineering, Inc. equipment is used by the Aviation Industry and the United States Government for all types of test.

Stratosphere Chambers and Rooms to 60,000 feet.

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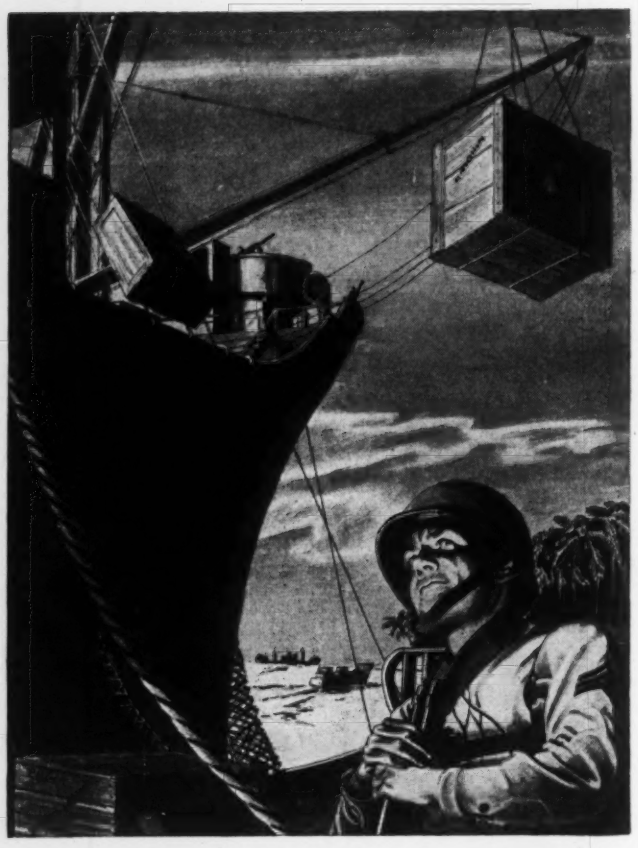

DELIVERIES **FOR** YOU...
INSTEAD OF **TO** YOU...

● Although everything we make today goes to war, it is going to work for *you* just as surely as though we could deliver it for your own use in your own plant. For today *all* of America is in business for Victory, and whatever helps the war effort helps us all. ✓ ✓ ✓ Right now "Connecticut" equipment is hard at work all around the globe — precision electrical products, different in detail, but not in basic design, from the ones you'll be using after victory. ✓ ✓ ✓ Once this war is won, and present military secrets become open knowledge, you'll know about "Connecticut" products from your partners, the boys who are using them today. Chances are you'll be using many electrical devices, born of this war, to speed and control peacetime production. We hope to continue working with you then.

CONNECTICUT TELEPHONE & ELECTRIC DIVISION

GREAT AMERICAN INDUSTRIES INC.

MERIDEN, CONNECTICUT

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D. P. Blanchard, Rome, New York; H. C. Hackley, Palo Alto, California; and S. S. Jackel, New Haven, Connecticut.

Our new decals for automobile windshields have arrived and every member will receive his as soon as your secretary can get them in the mail.

We have been swamped with so many applications that it is difficult to find enough time to run them through as fast as we wish, but we will get around to each and every one as soon as possible.

Many letters have been written to various manufacturers by your President, Mr. Ojers, on behalf of the Guild members and they are beginning to bear fruit.

Through the generosity of one manufacturer, we have been assured that every member will be placed on his mailing list for all service bulletins covering the repair of his products.

We have every reason to believe that we will soon be able to acquire this service from other manufacturers in the near future.

Prospective members, please fill out all applications in full and in detail. This will enable the Board of Trustees to pass on them with more dispatch. We have and will return over sixty applications forms for additional information before proper classification can be made. Whenever more space is needed, attach an extra sheet. If you change your mailing address in any way, notify the secretary at once. A penny postcard is all that is necessary.

Emergency Rebushing of Reversible Gear of Chronometric Tachometer

By L. H. HARVAT
Spartan School of Aeronautics, Tulsa, Okla.

FIG. 1 shows part of the reversible gear of the Jaeger chronometric tachometer. Note that the hole (in the arm that fits over drive shaft) has worn egg-shaped. This worn hole is found in tachometers that have been subjected to long and severe service. (Don't forget to look for it when you service a Jaeger tac.)

To correct this in an emergency, the writer found that it was quite easy to rebush the arm in this manner: First

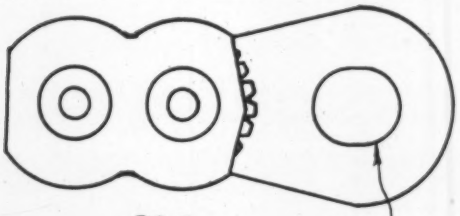

FIG.-1
SHOWING HOLE ELONGATED BY WEAR

FIG.-2
DRILLED FOR TIGHT FIT FOR JAEGER BUSHING #846

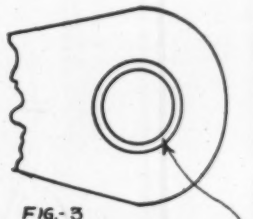

FIG.-3
#846 BUSHING IN PLACE - FLUSH WITH SURFACES

draw the temper on arm only, then drill out the egg-shaped hole (Fig. 2) so that a stabilizer-retaining-collar (Jaeger No. 846) can be pressed or driven in tight. This stabilizer-retaining-collar is thicker than the arm, so that one side can be driven flush with the arm and the other side ground or filed even with the arm, and then both sides polished to take off the blue color and make the job as smooth as a new arm. See Fig. 3. The inside diameter should fit the shaft almost perfectly. It may need broaching to remove burrs caused by driving the collar into the arm. The retaining collar supplied by Jaeger is hard-tempered, so the bearing again is hard and will wear for some time without giving any trouble.

IF YOUR PIVOT POINTS DO THIS

IT'S TIME TO SPECIFY

PERMOPIVOTS*

PERMOPIVOTS are tipped with Permometal*, a special alloy which is exceptionally resistant to wear . . . is non-corrosive . . . non-abrasive . . . and often eliminates oils for lubrication. Permopivots are made to exacting specifications. They will increase the life and accuracy of nearly all precision instruments.

*T. M. REG. U. S. PAT. OFF.

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MANUFACTURING METALLURGISTS

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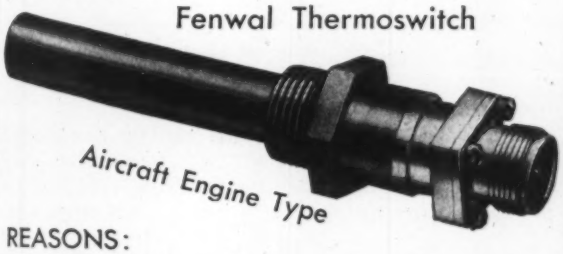
PROJECT 1763

PROBLEM: Unstable Thermostatic Control due to Vibration

SOLUTION:

Fenwal Thermoswitch



Aircraft Engine Type

REASONS:

The design is such that the element has high spring tension at all times. Consequently the expanding member (the outer shell) has positive, direct control of the contacts resulting in a definite vibrationless break on circuit open or closing.

Maximum rating 10A., 115V & ±.1°F. Sensitivity. Higher capacity and greater sensitivity available. Write.

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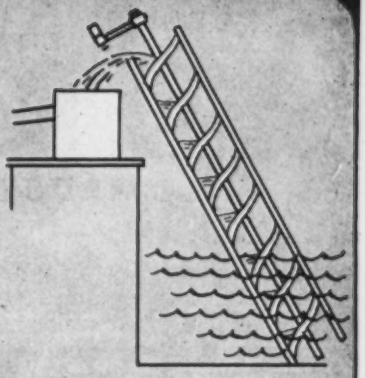
in 287-212 B.C. Archimedes

Is said to have told Hieron, the tyrant, to illustrate the principle of the lever. "Give me a place to stand and I will move the world."

Is credited with inventing the machine known as the Archimedes screw.



Today

Busy men, working in laboratories and plants, have at their finger tips scientific instruments to speed their work. In the field of measurement

MERIAM INSTRUMENTS

are widely used. One of particular interest is the low differential Inclined Tube Indicating Flow Meter for measuring air, gas, water, steam and other flows. Due to the use of an inclined tube, the scale length is increased for a given differential and greater accuracy in reading is obtained.

These instruments are available in many ranges for line pressures up to 150 lbs. per sq. in. The unit is furnished complete with mounting bracket of plate glass cover. Meter body is of cast construction. Ask for Bulletin A.

THE MERIAM COMPANY

1971 West 112th St. Cleveland, Ohio

MERIAM

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MANOMETERS, METERS AND GAUGES FOR THE ACCURATE MEASUREMENT OF PRESSURES, VACUUMS AND FLOWS OF LIQUIDS AND GASES

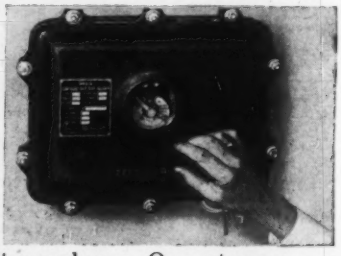
3 ways to BETTER PLANT SAFETY . . . .

Through Accurate, Continuous Gas Determination!

M·S·A COMBUSTIBLE GAS INDICATOR

Portable, easy to use, for quick and accurate sampling and testing of flammable gas or vapor-in-air mixtures for explosibility—requiring only a few seconds to make a test. Direct-reading in percent of lower explosive limit; also shows if atmosphere is within the explosive range, or above upper explosive limit. Widely used in checking tank atmospheres, pipe line leaks, etc. **Bulletin DM-2.**

M·S·A COMBUSTIBLE GAS ALARM



This instrument provides high precision in combustible gas determination, and can be used with an external pump capable of drawing samples through multiple lines over long distances to a convenient central location, remote from hazardous atmospheres. Operates any type of electrical warning signal; can be employed for ventilation or process control, and may be used with recording potentiometer. **Bulletin DT-1.**

M·S·A MULTIPLE SAMPLING COMBUSTIBLE GAS ALARM

A complete panel installation for continuously measuring combustible gas hazards at a number of sampling points, employing the M.S.A. Combustible Gas Alarm with multi-way sampling valve. Valve enables analysis of four, six or eight localities by the single alarm; rotating indexing drum automatically shows by visible number the line under test at any time. A recording potentiometer can be provided for continuous record of combustibles present in sampled atmospheres. Installation is furnished assembled. Details on application.

Demonstrations Gladly Arranged on Request

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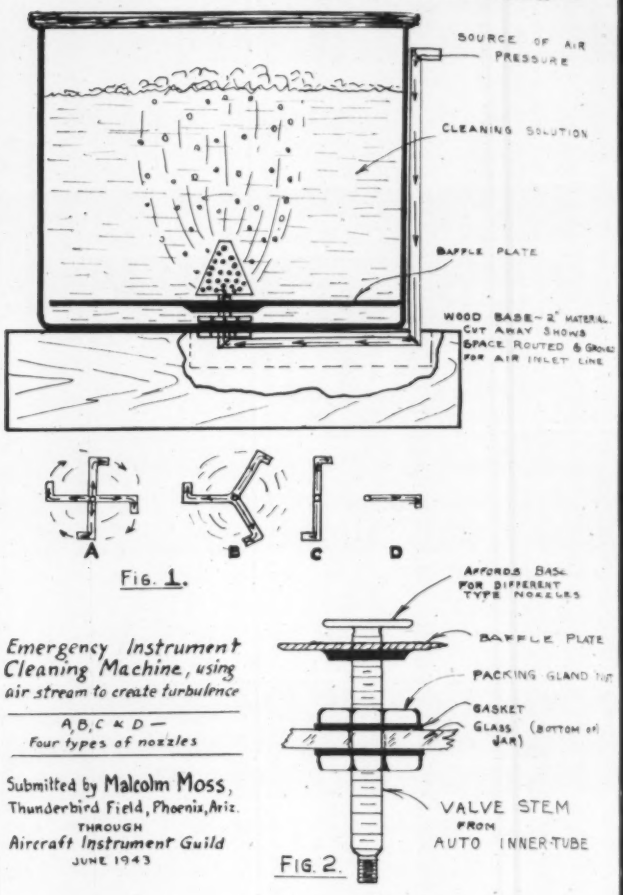

FIG. 1.

Emergency Instrument Cleaning Machine, using air stream to create turbulence

A, B, C & D — Four types of nozzles

Submitted by Malcolm Moss, Thunderbird Field, Phoenix, Ariz. THROUGH Aircraft Instrument Guild JUNE 1943

FIG. 2.

The A.I.G. Q&A Column

Conducted by E. M. ALLSMAN

Recorder, Aircraft Instrument Guild

Q. Is the Mark IV Automatic Pilot the same as the A-4 Automatic Pilot? (W. J. S., New York.)

A. The Mark IV is the Navy version of the A-4 Automatic Pilot and, according to our files, they are the same. I shall attempt to have more information in the near future concerning the term "Mark" as applied to instruments.

Q. I am having trouble with a dual Autosyn installation. When I close the circuit, pointer R *assumes a position of about ⅛ turn clockwise and pointer* L *settles on zero. When the transmitter is actuated,* R *moves counter-clockwise and comes back to zero after full-scale movement of the transmitter rotor while* L *moves clockwise about ⅛ turn and then goes counter-clockwise, stopping nearly ⅛ turn to the left of zero. If the current is turned off and then turned on, the pointers assume the original position. (B. I., Missouri.)*

A. Judging from your description, I believe that if you reverse leads *A* and *G* on the indicator you will remedy the trouble.

Q. Can you supply any information concerning the new method of compensating remote indicating compasses?

A. The advent of the remote reading compass has brought with it the Coefficient Method of Compensation. Theoretically it permits deviations to be analyzed and corrected in a more proper manner. Its application is based upon the five (5) coefficients A, B, C, D, & E. Unless installation is faulty, use will normally be restricted to A, B, & C.

To determine the coefficients it is necessary to ascertain the actual deviations when on the specific magnetic headings

RESISTORS IN THE AIR

In the new Bendix RTA-1B two-way telephone for aircraft and ground station service, WARD LEONARD, wire wound vitreous enamel resistors are used. They were selected because of their proven dependability under all conditions.

Ward Leonard Engineers are at the service of every manufacturer of equipment using resistors. They will gladly suggest the resistor from the Ward Leonard line that will not only give you the best possible service but will be best adapted for the conditions of assembly.

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Electric control (WL) devices since 1892.

WARD LEONARD ELECTRIC CO., 38 SOUTH ST., MOUNT VERNON, NEW YORK

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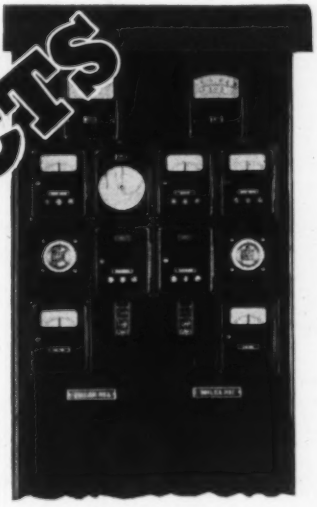


You get far more from Hays Automatic Combustion Control than just an accurate statement of facts. You get a Control System which automatically makes certain *that the facts are what you want them to be.*

Your boiler room may show similar vital savings. Ask Hays to make a survey and recommendation—there's no obligation and it's usually worth while in savings. The new Combustion Control Catalog is full of valuable data, write for it.

THE HAYS CORPORATION
COMBUSTION INSTRUMENTS AND CONTROLS
MICHIGAN CITY, INDIANA, U.S.A.

Wheelco ★

"Electronic Principle"

TEMPERATURE CONTROL

★

Plus PROPORTIONING CONTROL

★ *means* material waste through spoilage is stopped, vital man hours are saved and production increased.

Proportioning Control automatically operates to balance the fuel input with fuel demand to maintain the temperature desired—eliminating overshooting and undershooting of temperature.

"Electronic Principle" Temperature Control provides faster, more accurate control than any other type of control. Freedom from any interlocking between indicating and control systems assures instantaneous control action at all times.

Combined these two systems provide closer control than that possible with two or three position controllers.

The Wheelco Proportioning System may be incorporated and integrally mounted within any Wheelco "Electronic Principle" Temperature Controller.

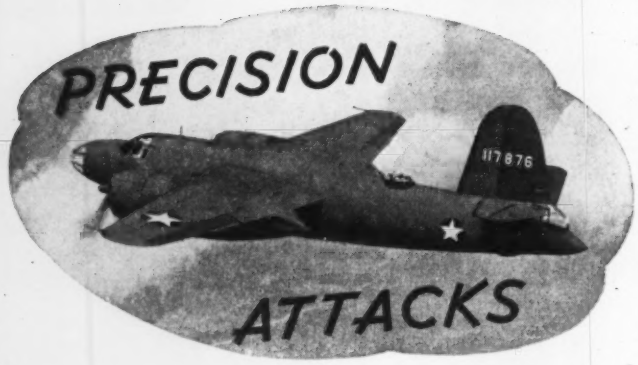
Request your copy of Bulletin D2-3 for full information.

Wheelco Instruments Co.

833 W. Harrison Street **Chicago, Illinois**

Originator of

"Electronic Principle" Temperature Controls



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Reliance Products

have both a war and peace-
time record of service.

BARBOUR STOCKWELL COMPANY
CAMBRIDGE, MASSACHUSETTS

NEW MEAD AIR-CLAMP

For
GREATER DRILL-PRESS OUTPUT

PROMPT SHIPMENT

WHEREVER a drill comes down, *something* must hold the work. Wherever a drilling jig is required, *Air-Clamp* will simplify it. Wherever *speed* is desired, *Air-Clamp* will produce it. *Air-Clamp* holds with relentless pressure; it is undisturbed by size variations (such as in castings) it scoffs at vibration (how many drills have been broken due to faulty holddowns?), chatter, snagging. *Air-Clamp* holds work of any size or shape in any position, at any angle. It can pay for itself on a single fixture; it can save its costs on a few days' drill-press output. It reduces operator fatigue. It saves hours and dollars in drafting-room, jig department, tool room and production line. *Air-Clamp* fits any drill-press having a cylindrical column. Special fixtures for Tee-slotted tables, light milling work, etc. Hand and/or foot control. Shipped on approval to responsible concerns.

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For air-operated devices. Frees hands—Speeds up work! Two types: Model "ON" releases work when pedal is pressed...Model "OFF" holds work when pedal is pressed. Low priced. Write!

MEAD SPECIALTIES CO.
15 South Market St. Dept. IA-63 Chicago

North, Northeast, East, Southeast, etc. The coefficients are calculated as follows:

$$\text{Coefficient } A \text{ equals } \frac{N \text{ plus } E \text{ plus } S \text{ plus } W}{4}$$

$$\text{Coefficient } B \text{ equals } \frac{E \text{ minus } W}{2}$$

$$\text{Coefficient } C \text{ equals } \frac{N \text{ minus } S}{2}$$

$$\text{Coefficient } D \text{ equals } \frac{NE \text{ minus } SE \text{ plus } SW \text{ minus } NW}{4}$$

$$\text{Coefficient } E \text{ equals } \frac{N \text{ minus } E \text{ plus } S \text{ minus } W}{4}$$

The upper right (detachable) portion of the card:—

The left-hand column contains corrections to be applied algebraically to the compass readings to determine the magnetic headings. The right-hand column contains corrections to be applied algebraically to the magnetic headings of the aircraft to determine the corresponding compass heading.

Compensation:—

Remove the compensating drawer or set the compensator assembly for zero effect.

Take readings on each of the four (4) cardinal headings and enter them in the appropriate spaces of the correction

	Compensating Swing			Residual Swing		Aircraft Comp.	Date	
	Actual Head (M)	Aircraft Comp.	Dev'n	Actual Head (M)	Aircraft Comp.	C to M		M to C
N 000							000	
NE 045							045	
E 090							090	
SE 135							135	
S 180							180	
SW 225							225	
W 270							270	
NW315							315	
	(1)	(2)	(1)–(2)	(3)	(4)	(3)–(4)		(6)–(5)

If swinging compass used ahead of aircraft add or subtract 180 degrees.

Coeff. $C = \frac{N-S}{2} = \frac{(\quad)-(\quad)}{2}$

Coeff. $B = \frac{E-W}{2} = \frac{(\quad)-(\quad)}{2}$

Coeff. $A = \frac{N+E+S+W}{4} = \frac{(\quad)+(\quad)+(\quad)+(\quad)}{4}$

Pilot's compass correction card. (Note—Other side, not reproduced, has blanks for aircraft, compass, date and signatures.)

form. Subtract the compass readings from the corresponding magnetic headings to obtain the deviations and enter the deviations with their signs in the "Deviation" column.

Now algebraically calculate the coefficient according to the formulae.

Head the plane to magnetic North and add coefficient C algebraically to the reading to determine the compensated indication. Replace the compensating mechanism, if removable type, and compensate the instrument to this reading.

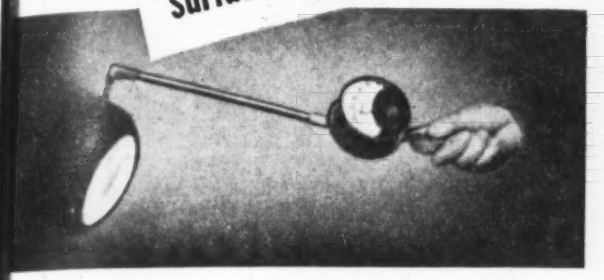
Head to magnetic East and add coefficient B algebraically to the reading to determine the compensated indication and adjust the instrument accordingly. It this materially changes the reading on North, it will be necessary to repeat the procedure for magnetic North compensation.

With the plane on any heading, add coefficient A algebraically to the indication to determine the compensated reading and compensate by rotating the compass itself; clockwise, if coefficient A is positive or counter-clockwise if coefficient A is negative. (This is not practical when the compass is mounted in an instrument panel and may be disregarded.) The compass is now compensated.

Take readings every 45° and enter the results in the "Residual Swing" column.

Follow instructions at the bottom of the last two blank columns to complete the form, tear off the compass card and place in the Aircraft Holder.

Alnor IMPROVED PYROCON for quick accurate surface temperatures



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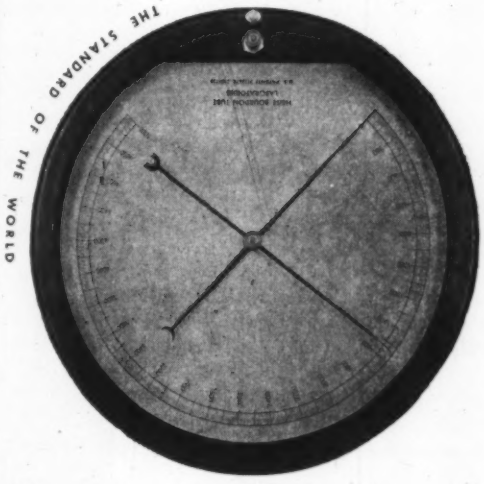

EVERY DAY we are shipping these precision pressure gauges to be used in place of dead weight testers. They are accurate, dependable and easy to read. Delivery—2 to 6 weeks.

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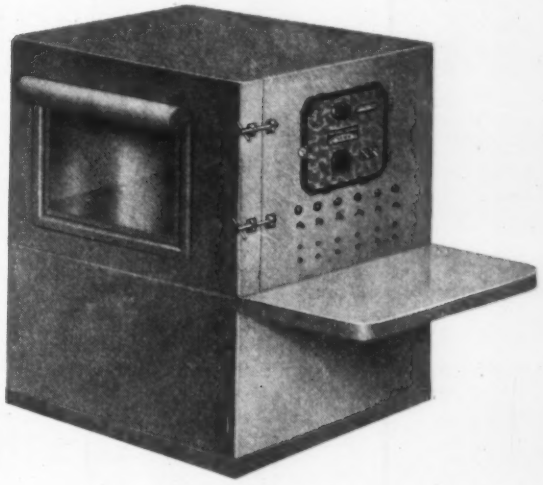
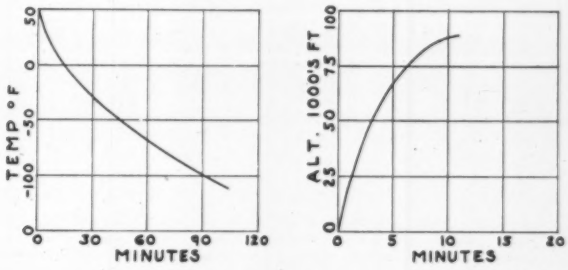


Operational Condition Test Equipment

Army, navy, air corps, and C. A. A. specifications for Electronic products as well as instruments and their component parts require operational condition testing—cold, heat, dust, humidity, salt spray.

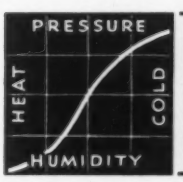
Whether for development work or for production testing calibration, Northern Engineering Laboratories can supply you quickly with standard or custom built test chambers which will provide all of the atmospheric conditions your specifications require.

Model NEL135-43 is typical in performance—−100°F to +160°F; 20% to 95% R.H. in the physical range; altitude simulation from sea level to 80,000 feet. (½" Hg. absolute) The graphs below show actual flight simulation curves of performance of the unit pictured above.



Rugged construction—complete shock and vibration isolation—Electronic indicator controller—full view observation window—fully automatic operation—high and low frequency electric connections from instrument panel to chamber interior—temperature controlled to plus or minus 0.2° F of selected temperature—fully mechanical refrigeration with complete refrigeration control—Freon 22 refrigerant—feature this laboratory instrument.

For complete details write for bulletin No. 20.



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Manganese
ALLOY
No. 772

In the illustration above is shown a simple test that compares the heat transfer of Chace No. 772 Alloy with some common metals. One end of each rod was submerged in boiling water and temperatures read at exposed end with a room temperature of 80° F. Note that the increase of temperature over room temperature of the exposed end, of the copper rod, for example, was approximately five times that of Chace No. 772 Alloy rod. The drop in temperature in the copper rod was less than 10% as compared to a drop of over 50% in the Chace No. 772 Alloy rod.

The thermal conductivity constant (cal./sec./cm²/°C/cm) of 0.02 is far below the value of ordinary metals or alloys, and thus makes Chace No. 772 Alloy ideal for low heat transfer applications. Bulletin A-942, giving detailed information on the physical properties of Chace Manganese Alloy No. 772, sent on request.

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Instruments in the War Effort

Remote Control Speeds Testing of Motors for U. S. Aircraft

A NEW and more efficient method of testing and breaking in aircraft engines was revealed when engineers of the Minneapolis-Honeywell Regulator Co. announced the installation of more than 100 sets of special control devices and recording instruments in one of the nation's newest and largest airplane engine manufacturing plants. For the first time in the history of the aircraft engine industry, definite control of the entire engine-testing sequence can be managed by one man from a single control point, said John Haines, manager of the air-conditioning controls division of the company. Previous methods required the constant attention of at least two highly-trained engineers and an assistant to record operational data, he stated.

More than 500 test cells using the Minneapolis-Honeywell controls are already in operation or nearing completion, he said. These include Allison and Buick. In addition, many plane manufacturing plants are utilizing the new equipment to speed production and obtain more accurate records on motors going through tests and modifications.

Tests are conducted in special rooms called test cells found in every plant manufacturing engines and at Army and Navy Air Bases and Depots. The test cell itself is extremely complicated, Haines said. Fuel lines, oil lines, air ducts, throttle controls, temperature and pressure measuring instruments and a maze of wires and tubes necessary to start and control the motor are attached to permanent connections within the cell. These connections are remotely controlled by the company's specially designed switches, controllers, motors, dampers and valves so that a test engineer may sit outside of the test cell and maintain complete control of the motor undergoing tests without ever getting near it from his desk which is protected from the motor by three windows of heavy shatter-proof plate glass. The test engineer can simulate all the varied conditions the motor might encounter when flying from 1,000 to 40,000 feet and from tropic heat to sub-freezing temperatures.

Each of the new test cells has more than 40 pneumatic control valves, Haines said. Other switches, controllers and valves control carburetor air temperature and pressure, gasoline flows and temperature, engine cylinder temperatures, singly or in groups, oil flows and temperature, cowl ventilation and Prestone and oil temperature control for liquid-cooled engines. Two of the three men required to run earlier test cell equipment manually adjusted valves and switches, Haines continued, while the third read instruments and maintained all the necessary records on engine performance. Now, autographic instruments made by the Brown Instrument Co., subsidiary of Minneapolis-Honeywell, record operational data of the engine so that complete charts of its performance are available before shipment.

An Electronics Mystery Solved

THAT gas dissolves in certain metals just as salt dissolves in water may lead to the production of longer lasting electronic tubes which require less power to operate —such was the discovery reported to the American Physical Society by Dr. Harvey C. Rentschler, Director of Research for the Lamp Division of Westinghouse. To his fellow physicists he reported the results of his experiments to unravel one of the unsolved mysteries of electronics, namely

electrons are emitted from metals to set up a flow of rent inside such tubes as those for radio and X-ray.

xperiments during the last eight years have led to the clusion that atoms of gas—oxygen, hydrogen or nitro—actually dissolve in the crystalline structure of some als just as salt dissolves in water. These gas particles n "loosen" the electrons in this structure, causing them e emitted from the metal more readily when heat or t is applied.

This explanation," Dr. Rentschler declared, "should re- t in longer-lasting tubes and accomplish important sav- s in the size and number of electric batteries, generators other apparatus needed to supply the filament power. ch improved tubes would be the result of better cathode struction," he continued.

Dr. Rentschler first discovered, in 1935, that a small ount of oxygen reacting with such metals as thorium, nium and barium speeded electron emission, but found t a similar effect was not obtained with commoner metals h as iron, nickel, copper, zirconium, titanium and others. sing a pure form of zirconium, titanium and hafnium," explained, "we now have found that these metals, too, likewise affected by oxygen as well as nitrogen and drogen.

When these metals in a pure state and mounted on a e of tungsten are heated in a vacuum, they will melt into soft globule. When the pure metal is heated in oxygen, drogen or nitrogen at a low temperature and then at a ll higher temperature in a vacuum, it becomes brittle and rd.

After an appreciable amount of gas is 'dissolved' in the tal and all excess gas removed, the metal can be heated temperature as high as 2,700°F. The fact that there is pressure increase in the vacuum tube shows that no fur- r gas is liberated. The gas apparently dissolves uniformly form what we call a 'solid solution' in the metal. From h metal can be made excellent cathodes."

Although physicists had known that oxide-coated cath- es emit electrons more readily than cathodes of plain tal, they had been unable to use oxides for high voltage bes, Dr. Rentschler pointed out. This is because the high ltage sets up such a strong electric field that the oxide- ating is torn from the surface of the metal. Such a coat- consists of a paste baked onto the metal.

By dissolving gas into the metal, however, it may be pos- le in the future to produce an oxide-coated cathode for gh-voltage tubes, he continued. The oxide in this case be- mes an integral part of the basic cathode metal and can- t be torn off by the strong "pull" of the electric field.

Instrument Pivots and Bearings

Concluded from page 340

e form of oscillation is at its worst when you decelerate d reverse very suddenly by hitting the boxes. The prac- al lesson we learn is that the aim of vibration engineers not only to "reduce" vibrations but to transform rough ructural vibrations into "smooth" panel-board vibrations. he smoothest form is known as harmonic motion; it has e smallest acceleration values for a given amplitude and equency; it is represented on paper by the familiar sine rve of an ideal alternating current. The roughest form is e so-called square wave which theoretically implies infi- te speed, rest, infinite speed in the other direction, rest, nd so on.

Modern vibration-engineered panel-boards have nearly erfect harmonic oscillations. The mountings absorb high cceleration values and protect all parts of instruments at are rigidly fixed to one another. But, as the first three xperiments demonstrated, looseness means rattling, even hen the constantly-recurrent *G*'s have extremely small alues. The looser a bearing, the greater the impacts; the maller the contact area, the higher the unit stress. That is hy such strong materials as those of pivots and jewels are *cally* weakened and injured by vibrations.

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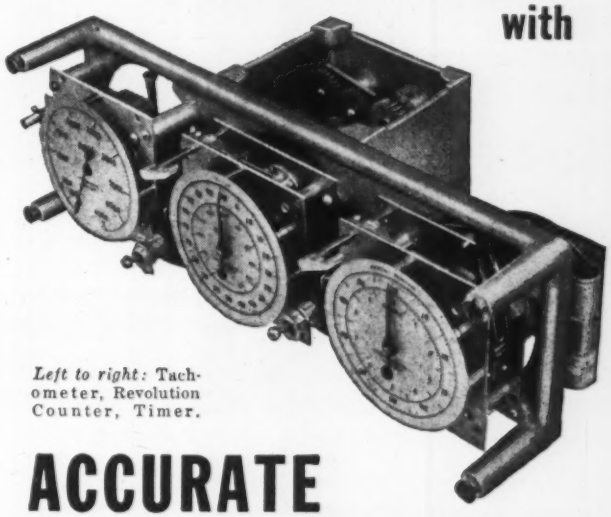

Left to right: Tachometer, Revolution Counter, Timer.

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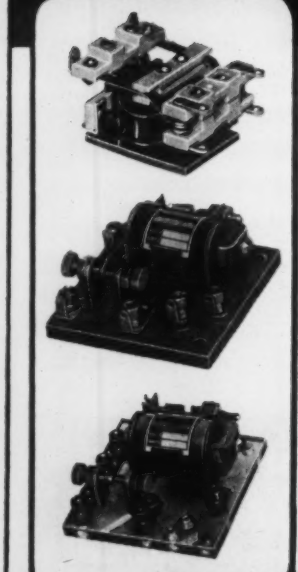

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Continued from page 338

This unilateral conducting property of the diode enable it to serve as a rectifier of alternating current. If an alte nating potential is applied to the plate, as shown in Fig 13 and 14, the plate will be made alternately positive a negative. Since the tube conducts current only when t plate is positive, the negative half of the cycle is suppresse and there will flow in the plate circuit a pulsating curre of the type shown at B in Fig. 14. A single tube of th

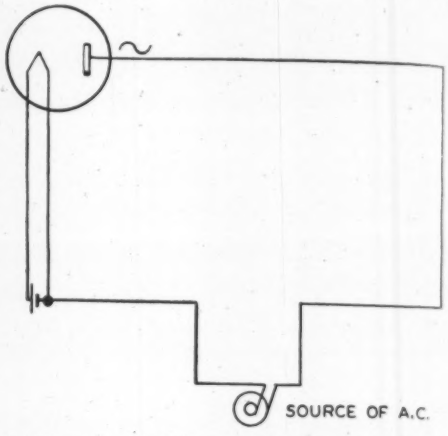

Fig. 13. When an alternating potential is applied to the plate, current will flow only during the successive half cycles when the plate is positive.

kind, therefore, constitutes a half-wave rectifier and as such it has been extensively applied in the charging of storag batteries. The "Tungar" and "Rectigon" battery charger in universal use today employ rectifying tubes of this gen eral type.

This rectifying principle of the two-element thermioni tube or diode was first recognized in 1905 by John A. Flem ing in England. At that time Fleming was engaged in th development of a system of wireless telegraphy and ob tained a patent on the use of the "vacuum tube" as a de tector of high-frequency electrical oscillations. This patent

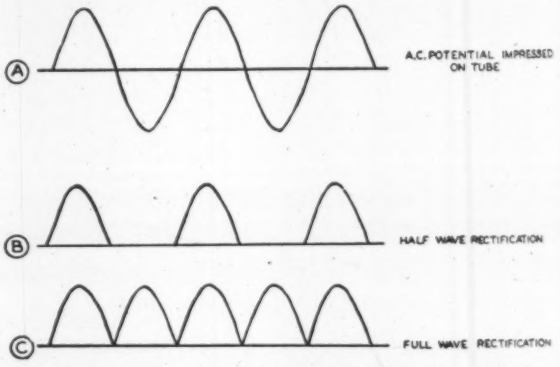

Fig. 14. Wave diagrams showing half the full-wave rectification.

is one of the most fundamental patents in the entire history of electron tube development. From this rectifying property also is derived the English term valve to designate the electron tube.

The arrangement shown in Fig. 13 provides half-wave rectification. Where it is desired to produce full-wave recti fication, two tubes, or a modified form of tube having two plates, may be used in circuits such as shown in Fig. 15. Although two tubes are used at A, only one is in use at one time. While the plate of one is charged positively the plate of the other is charged negatively; thus, while one tube is conducting the other is inactive. The instantaneous direc tions of currents in the circuit for two successive halves of the cycle are shown in Fig. 16.

We have now explained the first simple property and ap-

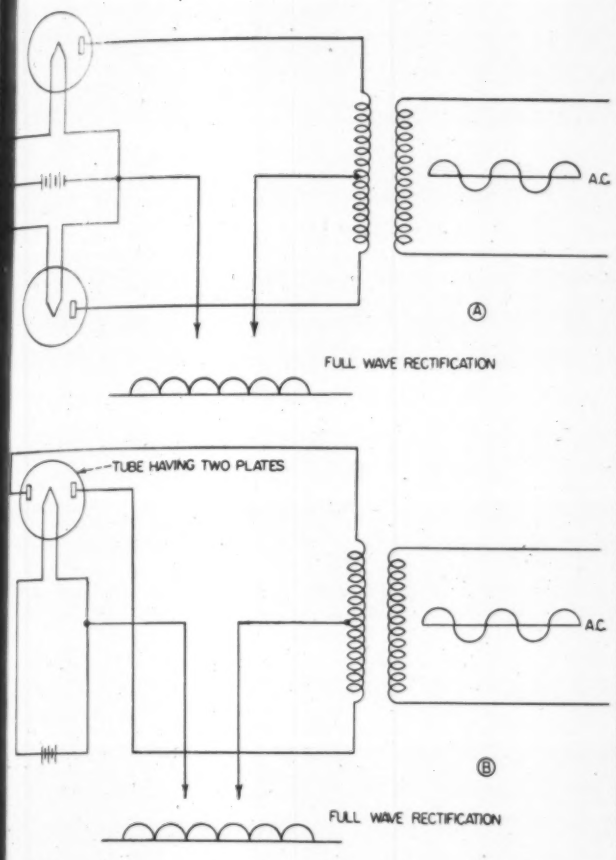

Fig. 15. (A) Diagram showing two diodes connected to give full-wave rectification. (B) Diagram showing how a single tube with two plates can be used to give full-wave rectification.

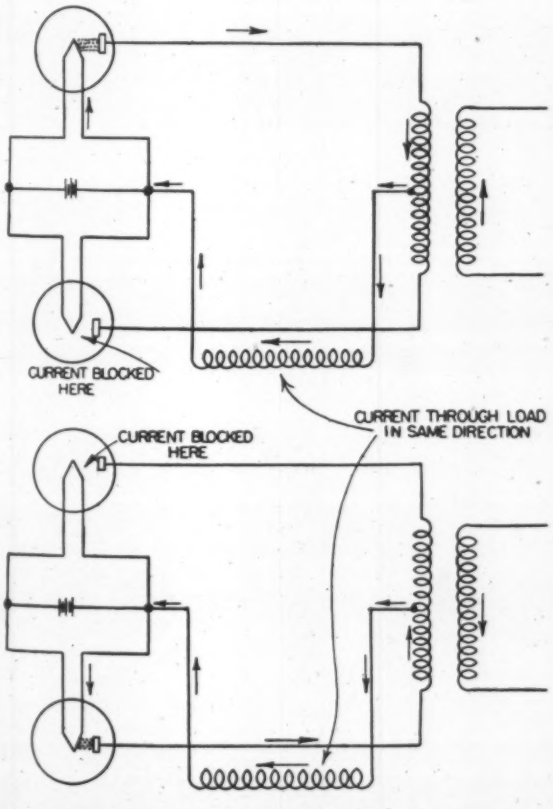

Fig. 16. Diagram showing the instantaneous direction of current in various parts of a full-wave rectification circuit during successive halves of the cycle.

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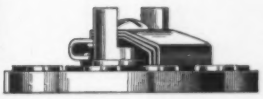

This is the shorting type. As the arm is rotated from one position to another the adjacent contact points are "shorted" (bridged).

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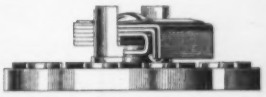
This is the non-shorting type. As the arm is rotated from one position to another, the arm lifts up, and only one contact is touched at a time.



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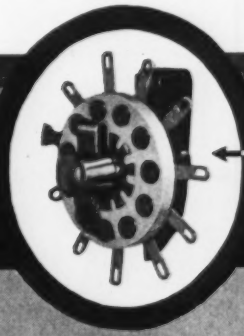

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plication of the electron tube. Surely there has been nothing about it that might be called difficult. Nothing that has required any profound knowledge of physics or electrical theory. Indeed, the whole thing is quite as easy to understand as is the action of a commutator on a motor.

In the chapters that follow, more involved properties of electron tubes will be discussed but if one understands the fundamental principles here outlined, no trouble should be experienced in grasping at least some of the more complex principles.

The tube we have considered is the diode—having only two primary elements. A tube with three elements is called a triode, one with four elements a tetrode and one with five a pentode. All tubes can be classified according to these general family names: diodes, triodes, tetrodes, pentodes, etc. However, there are many other names by which tubes are known. Thus, there are phanatrons, thyratrons, pliotrons, kenotrons and dynatrons, and there are grid glow tubes, cathode-ray tubes, x-ray tubes, high-vacuum and gaseous tubes, etc., and new types are continually making their appearance.

This variety of names is naturally confusing to the lay mind or to the electrical engineer not directly concerned with tubes, but it need cause no confusion if we consider tubes according to their function rather than by name—according to what they can do. Thus when we speak of an x-ray tube there can never be any doubt as to what is meant, though an x-ray tube might also be called a diode.

So in the beginning we shall not concern ourselves with the technical names which have been applied to various kinds of tubes but will endeavor to explain their action and indicate their purpose simply and directly as we come to them.

To be continued

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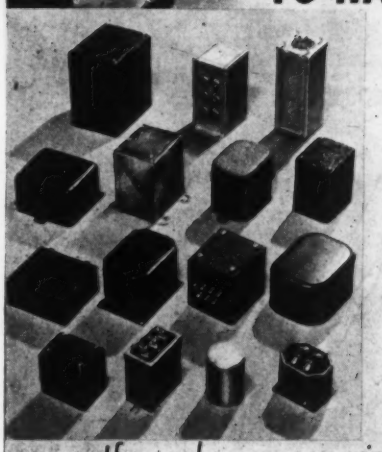

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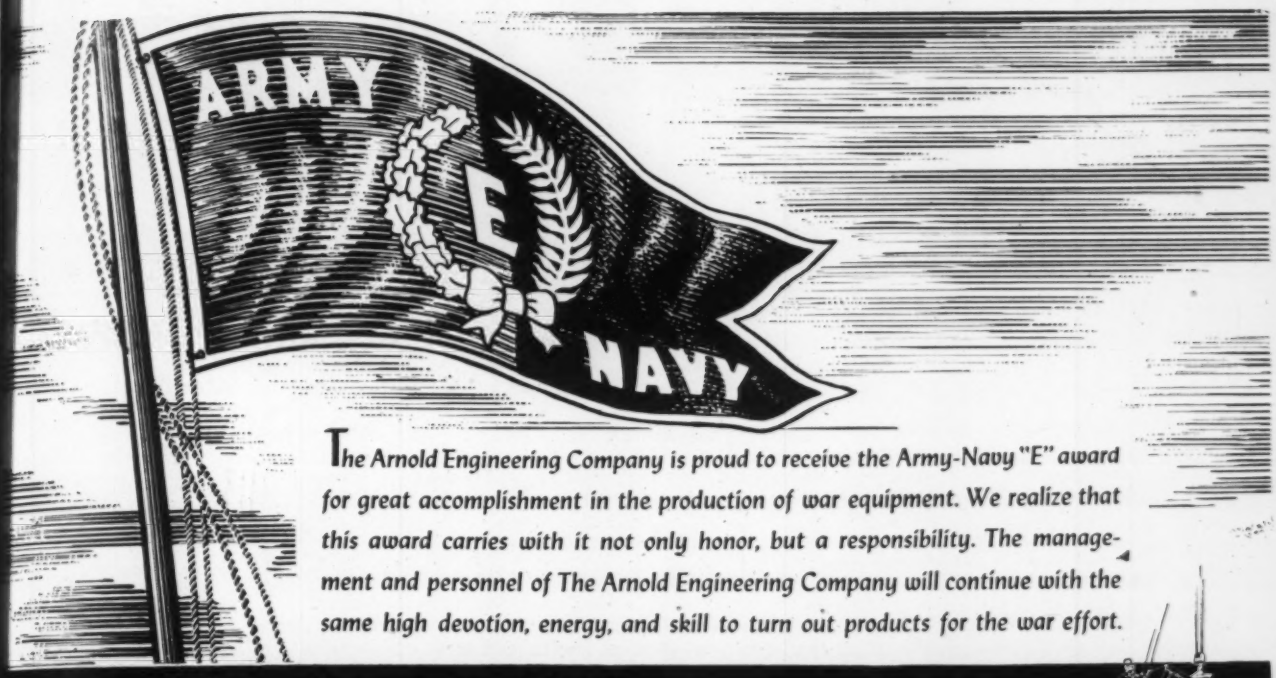

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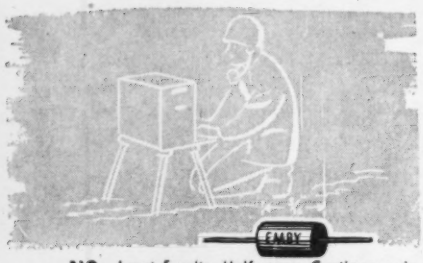

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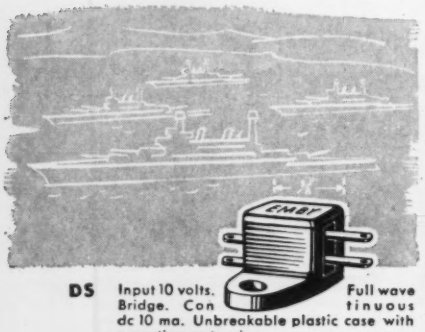
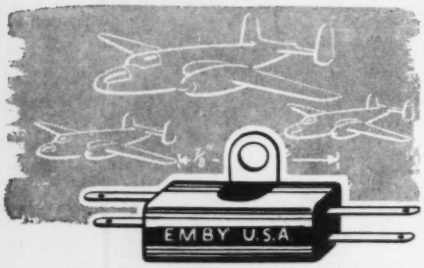


DS Input 10 volts. Full wave Bridge. Continuous dc 10 ma. Unbreakable plastic case with mounting extension.



DL Input 10 volts. Full wave bridge. Continuous dc rating 35 ma. Mounted in aluminum case with mounting extension.

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Instruments in the War Effort

Photoelastic Analysis Increases Strength of Turbine Bolts

THREE-DIMENSIONAL photoelastic analysis, applied for the first time to the ordinary nut and bolt, has shown how to increase the effective strength of huge turbine bolts as much as 40%. Dr. M. Hetenyi of the Westinghouse Research Laboratories reveals that the use of a nut with either tapered lip or tapered thread makes the

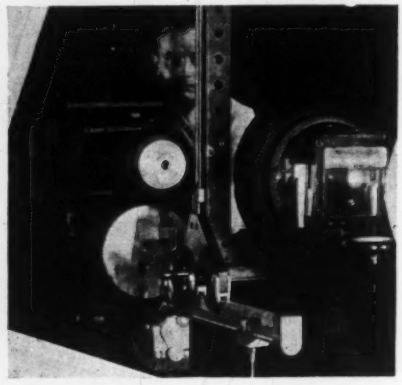

Fig. 1

effective strength of the fastening from 20 to 40% greater. Because turbines work at nearly 1000°F. — almost a cherry-red—the big bolts holding the parts together encounter extremely severe service conditions. Dr. Hetenyi made transparent Bakelite bolt models 1" in diameter (the steel bolts used on some turbines are 6" in diameter and

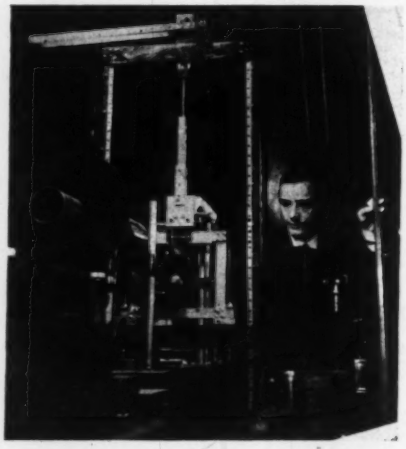

Fig. 2

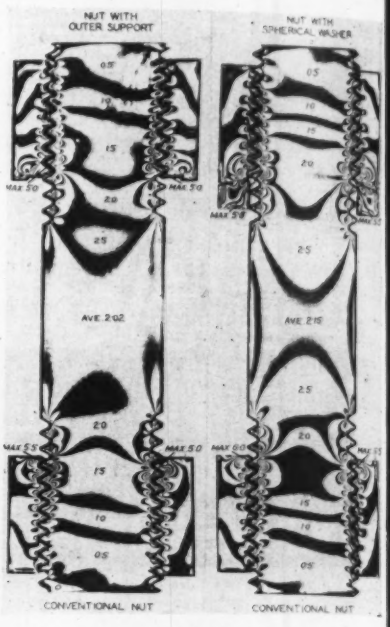

Fig. 3

weigh about 500 lbs.), applied nuts of different types and loaded them in the same way they would be loaded in service. (Fig. 1.) The stressed models then were annealed 3 hours at 120°C. and cooled to room temperature, after which a ⅛" thick length-wise slice (Fig. 2) was cut from the center of each. Stress lines or fringes, "frozen" into these slices by the annealing process, are made visible by the use of polarized light and show that the maximum stress, regardless of kind of nut used, usually is at the root of the thread nearest the bottom of the nut. (Fig. 3.)

Autographic Creep Test

AN automatic and autographic instrument now measures the rate at which metals flow when heated and stressed in the General Electric Research Laboratory. Not only does this release for other important work the attention of a man who formerly watched the metal sample through a microscope; it also is more sensitive than any human observer and more reliable. It never tires.

These measurements of the creep of materials are being made by Dr. Saul Dushman, assistant director of the Laboratory. Since a steam turbine, for example, operates with greater efficiency the higher the temperature, metallurgists try to create alloys which

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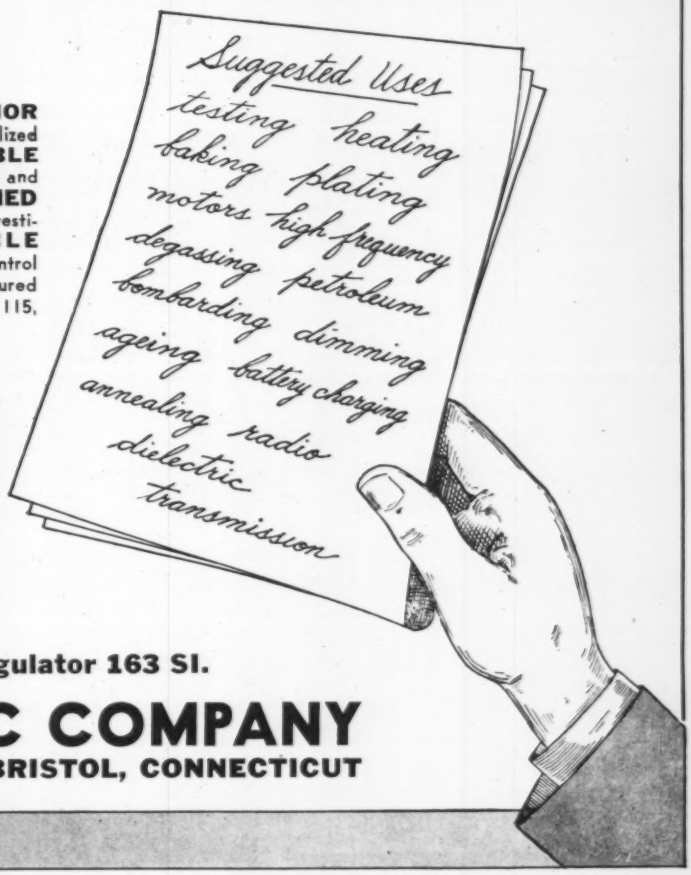

Bulletins: Powerstat 149 SI. Power Regulator 163 SI.

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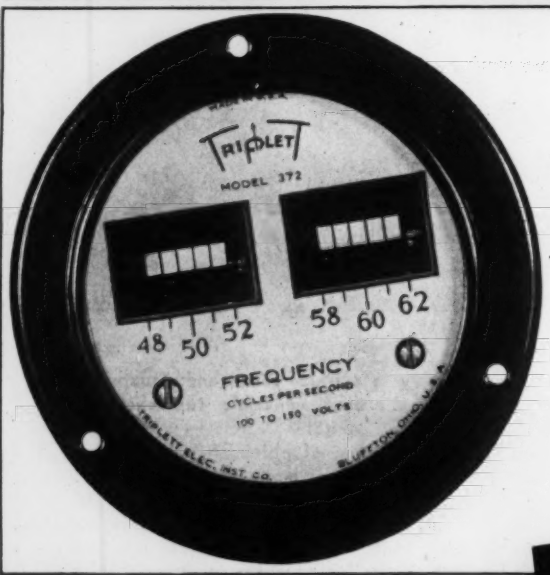
Combat Line INSTRUMENTS



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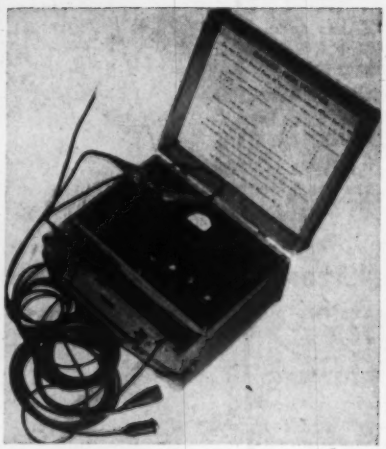

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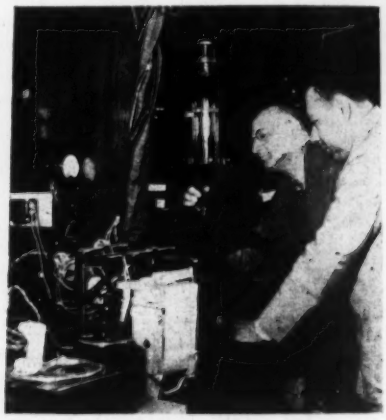
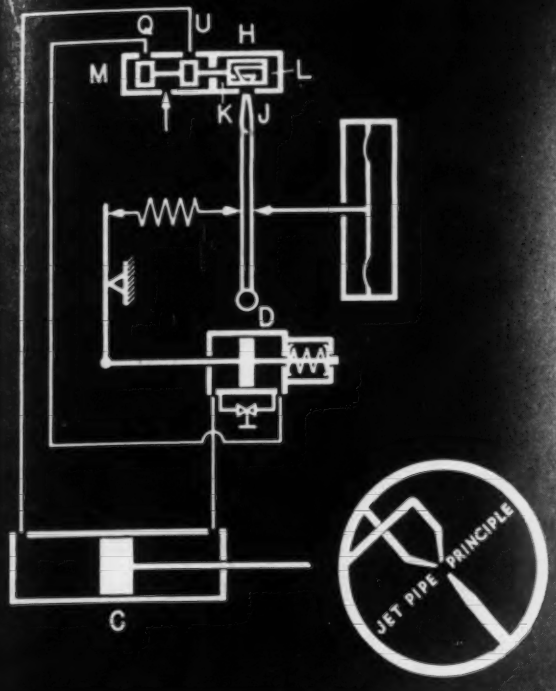
will hold their shape under high stress and the greatest possible operating temperatures. Dr. Dushman (left in photo) described an accelerated method for making creep tests. The conventional tests use a bar of the sample metal, which is heated in a special furnace to the range of operating temperatures, 800-1400°F. Such tests may require months to complete. The new method uses a thin wire of the metal conducting a current which heats it to perhaps 2000°F. The wire is enclosed in a glass cylinder which permits the tests to be made in nitrogen to preventing rusting. A weight is attached to the wire. Through a microscope focussed on the lower end, the observer watched and measured the slow stretching, perhaps half of one percent an hour. Data were obtained much more rapidly by this method than by the previous ones.

To make the measurements automatically, J. T. Mireles Malpica (right) Mexican-born engineer of the G-E General Engineering Laboratory, devised the robot; and the apparatus now used was constructed by Eric T. Asp, of the Research Laboratory. This device has



not yet been placed in production for commercial use. The operating principle of the device has been used successfully for years in measuring microscopic dimensional changes as in magnetostriction changes.

This principle may be demonstrated with a flashlight and two combs. Hold one comb over the lens of the flashlight, and you can shine a spot of light on a nearby wall. Now hold the other comb over the first, close to it with the teeth parallel, and move the second comb very slowly. When the teeth of one cover the openings of the other, the light is cut off. But when the second comb moves the width of a tooth, the clear spaces are lined up and light passes through. If the flashlight and first comb were firmly fixed, and the width of the teeth and openings were known, it would easily be possible to measure the movement of the second comb merely by counting the alternations of light and dark. This is what Mireles Malpica did. A light shines through a glass grid, ruled with horizontal black lines each 0.004" wide and the same distance apart. Attached to the bottom of the



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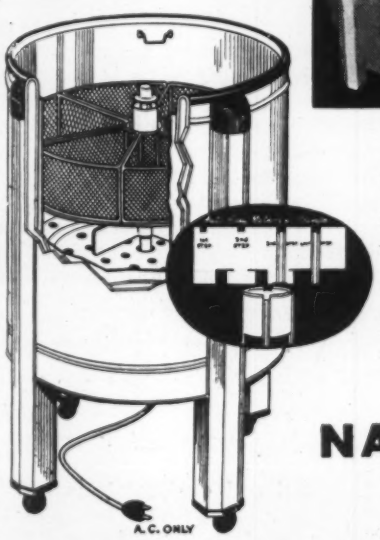

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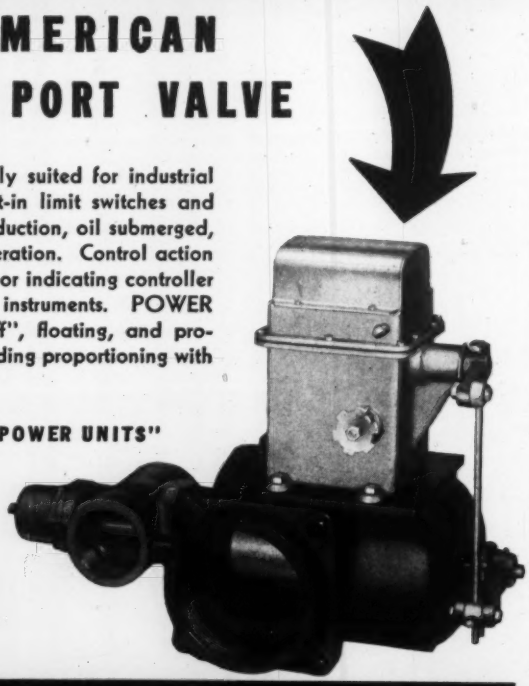

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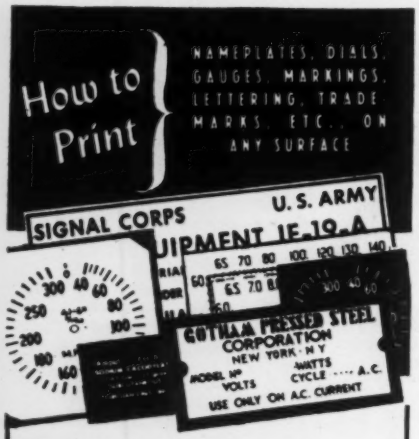

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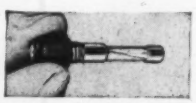
Same as above but finger-operated. Picture shows fuse inserted in knob. Two of many Littelfuse types.



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test wire is another such grid, nearly in contact with the first. A lens forms an enlarged image of these grids on the surface of a photocell. A sensitive recorder makes an ink-on-paper record of the changes in current from the photocell, hence in the changes in brightness or the movement of the second grid. In this way it is possible to measure an extension of the wire as small as 0.0001".

Woman Pilot Becomes Instrument Technician

Miss Ruth Young, 21-year-old flyer from Cincinnati, Ohio, shown while being interviewed by Earl C. Brady, TWA Field Representative, relative to employment as instrument technician at a TWA maintenance depot. She was one of the first women to take the Master Instrument Technician course at American School of Aircraft Instruments, Glendale, Calif.

"I first became interested in aircraft instruments when I did winter flying in Ohio," said Miss Young. "You really learn to appreciate the instruments on your plane when you are not sure of your position and visibility is poor. Wishing to know more about aircraft instruments, I came to California and found the Master Instrument Technician Course, at American School, just the course to give me the training I wanted. Since then, I have decided to make instrument maintenance my profession and hope to become employed by TWA as an instrument technician. I feel that the future in Aviation is unlimited; particularly in the field of aircraft instruments after the war."

TWA inaugurated the use of women instrument mechanics at its Kansas City maintenance headquarters in 1942.

Controller Safeguards Magnesium Grinding

MARKED production speed-up, together with safeguarding of personnel and equipment, is resulting from the installation of automatic feeder control for the pulverizing

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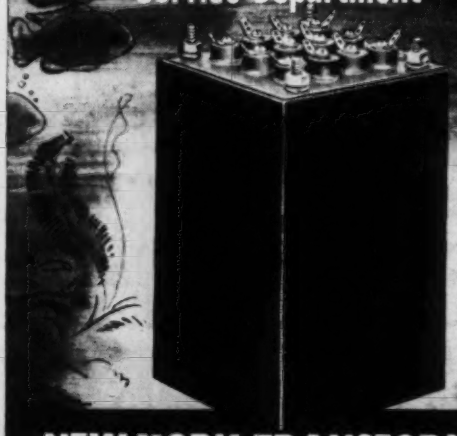
Embodying the very latest in design, its proportions have been engineered to permit maximum performance, while utilizing only a minimum of space.

The immersion-proof case has been custom-built to do a specific job, further illustrating the policy of the N·Y·T Sample Department of meeting individual mechanical and electrical requirements. Your inquiries are invited.



NEW YORK TRANSFORMER COMPANY
26-28 WAVERLY PLACE, NEW YORK, N.Y.

equipment of a magnesium plant engaged in war work. Developed and built by Max Mosher, New York specialist in grinding equipment, this automatic controller responds to the varying load placed on the driving motor and controls the feeding rate accordingly.

In this magnesium plant the controller regulates the rate of feed of magnesium shavings to the grinder which in turn converts them into fine powder. For reasons of safety the feeder and grinder are housed in separate buildings. Chips are carried from the feeder through a pipe by air suction. If the rate of feed is too great the grinder can become clogged whence possible burnout of the grinder motor and, worse still, danger of explosion from severe overheating. If the load on the grinder is reduced below full load, the grinding equipment is not being used to maximum efficiency and war production schedules suffer.

In installations of this sort there usually is a 20 to 30% gain in output while safeguarding equipment, particularly the grinder motor, and the product itself, against damage.

Minimization of attendant manpower is another advantage of automatization. An operator merely dumps magnesium shavings from a barrel into a hopper every half hour or so, while the hopper automatically feeds the grinder.

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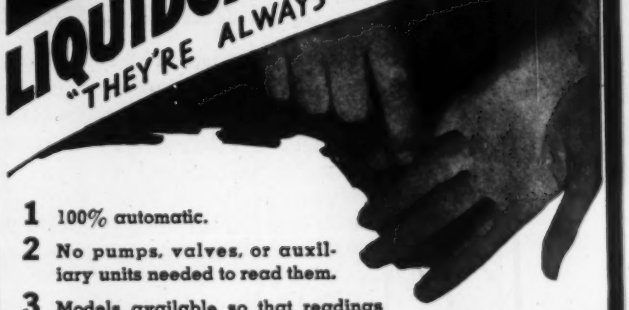

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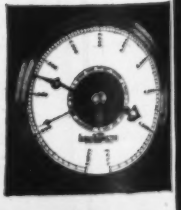

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For Securing Remote Electrical Indication from Mechanically Indicating Instruments.

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Compensation for the effects of changes of ambient temperature may be provided. Also compensation for effects of temperature change on associated equipment. Vibration proof and shock proof. Operates on either alternating current or on direct current with suitable provision. We are prepared to engineer Translator Unit into your equipment and to license application.

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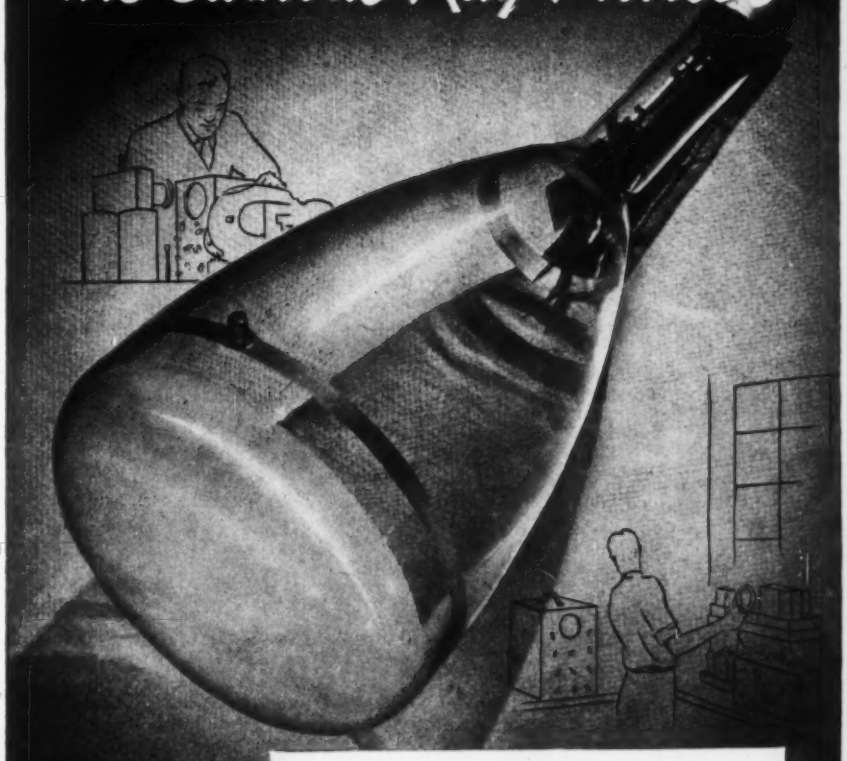
DU MONT

the Cathode-Ray Pioneer



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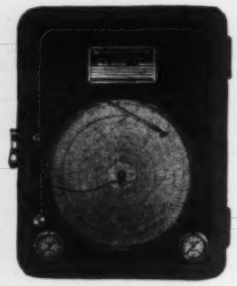
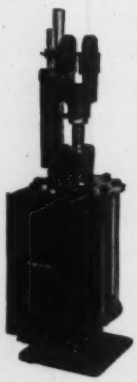


Recorder-Controller

Boiler Meters for recording combustion conditions and guiding boiler operators. Described in Bulletin No. 44.

Multi-Pointer Gages for indicating factors such as draft, pressure, temperature and speed. These Gages are available with any number of pointers and any scale combination; in either the oil sealed bell or diaphragm construction.



Control Drive

Flow Meters for indicating, recording and integrating the flow of steam, water, sewage, air, gas and other fluids. Bulletins No. 39 and 300.

Recorders for pressure, temperature, drafts, liquid level and other factors.

C-3

BAILEY METER COMPANY

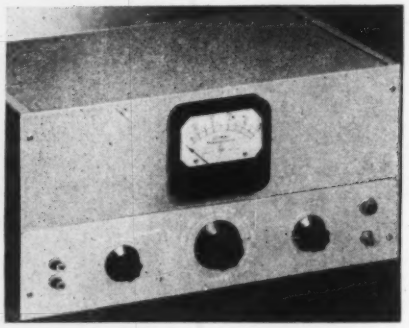
1041 Ivanhoe Rd., Cleveland, Ohio

The Month's NEW INSTRUMENTS

In this department we strive to report each month ALL the new devices for measurement, inspection, testing, metering and automatic control—in the form of concise technical descriptions. When writing to manufacturers directly, please mention this department. Or write to Information Section, Instruments Publishing Company.

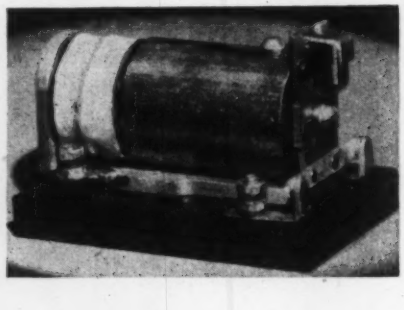
0-50-kc. Frequency Meter

New "Model 500A" Frequency Meter is designed to measure the frequency of an alternating voltage from 0 to 50 kc. It is said to be useful in making frequency measurements in both laboratory and production work. In frequency measurement work at higher frequencies it can be used to measure the frequency difference between two radio frequency signals. It is said to be particularly suited to crystal grinding work where it can be used to measure the frequency deviation from the standard quickly and accurately. It is said that its simplicity and accuracy make it useful in any electronic laboratory and invaluable in certain production testing applications. — *Hewlett-Packard Company, 694 Page Mill road, Palo Alto, California.*



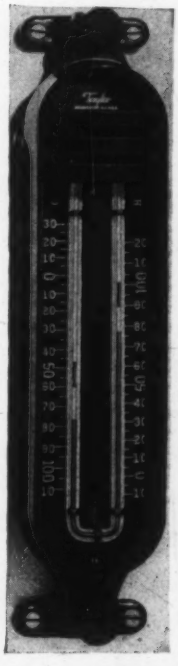
Time-delay Relay for Aircraft Applications

New time-delay relay, specifically designed for aircraft applications where time-delay drop-out is required, is available in two sizes, one providing up to 0.4 sec. time delay, and the other up to 0.3 sec. time delay. It is said that on many applications this relay can be used directly to control the desired device, while on others it may be desirable to have the relay actuate a contactor. To accomplish accurate time-delay, new relay employs the principle of delaying the decay of flux in a magnetic circuit through the use of a single-turn low-resistance copper jacket around a section of the magnetic structure. Designed for use in a wide range of ambient temperatures (95° C. to −40° C.) both sizes are suitable for mounting in any position, and corrosion-proof, withstanding 95% humidity at 75° C. on 48-hour tests and operating successfully immediately thereafter. Normally-closed double-break silver contacts will carry 2 amperes continuously at altitudes up to 40,000 feet. Operating coils can be furnished for operation on either a 12- or a 24-volt circuit. Whether the relay is energized or de-energized, its contacts will remain in correct position without chattering, it is said, even when subjected to mechanical frequencies of 5 to 55 cycles per second at 1/32" amplitude (1/16" total travel), applied in any direction, or when subjected to linear acceleration of ten times gravity in any direction.—*General Electric Co., Schenectady, N. Y.*

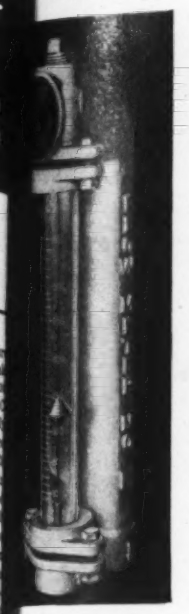


Maximum and Minimum Registering Thermometer

New Taylor Maximum-Minimum Thermometer in Tenite housing embodies various improvements: *(1) Material.* Instead of former sand cast Navy bronze housing with brackets of same material, weighing 21 oz. finished, molded Tenite case 8½ oz. This has eliminated the use of an extremely critical material and saves weight which in the aggregate is important (conserving for other purposes nearly 50 tons of critical bronze on one contract alone). *(2) Finish.* Finish of plastic housing is permanent, whereas Navy bronze, while resistant to salt water atmosphere corrosion, has to be polished continually. *(3) Improved Design.* Former case of Navy bronze was of box-like design with sharp edges and sharp corners, involved separate metal parts to protect thermometer bulb against breakage. Plastic construction permitted streamlining design and incorporating more efficient protection for thermometer. *(4) Elimination of Expensive Finishing Operations.* Former case required considerable grinding and preparation of the raw castings, fine grinding, polishing and buffing to produce a smooth finish. Plastic housing by eliminating all this made more man hours available for other work. *(5) Better Delivery.* Foundry work is slow. Plastic moldings speed up deliveries to less than half of time formerly required.—*Taylor Instrument Companies, Rochester, N. Y.*



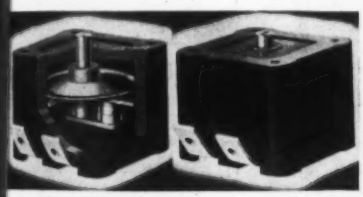
Flow-rate Indicators



Announcement of new indicating float type flow-rate indicators states that makers have improved and patented the design which they supply as shown in the adjacent illustration, by providing a central guide rod securely held by crowfoot fixtures at the top and bottom. This guide rod is said to eliminate wobbling and to make accurate reading easy. Float is also of a new design, consisting of opposed cones which give a streamlining effect that tends to steady or stabilize its response and to prevent an accumulation of foreign matter on top of or in it to affect the calibration. Spring ps top and bottom have a cushioning ion and prevent sticking of the float or nage to the gauge glass. New indicators supplied in various standard sizes up 1200 ft.³/hr. capacity, but can be sup- d for greater volumes and also for cer- n liquids.—*The American Gas Furnace mpany, Elizabeth, N. J.*

Sealed Switches

New "A3" and "A5" switches are sealed Bakelite cases to protect contacts against t, dust, sand and oil—said to be greatest ividual factor of switch failure. This itive protection feature is essential in trical control units for newest types of craft and ground equipment, especially use where climatic conditions cause fail- e of ordinary types of equipment. *Oper-*



ng Characteristics: Contact Arrange- nts: S-p.s-t., A3 normally closed, double eak; A5 normally open, double break. ntact Ratings: Non-inductive, 50 amps. 12 and 24 volts d.c. and 110 volts a.c. erating Pressure: 1½ to 3½ lbs. Plunger: avel differential 0.006" to 0.012". Over- avel: 0.050" to 0.070" at maximum pres- re. Vibration: 10 *G* for either horizontal vertical positions. Weight: 5 oz. Dimen- ons: $1\frac{13}{16}$" × $1\frac{13}{16}$" × $1\frac{13}{16}$".—*The Allied Con- ol Co., 2 East End Ave. (at 79th St.), New ork City.*

Monochromatic Inspection Light

Human eye being a non-achromatic lens, able to focus polychromatic light perfect- monochromatic illumination intensifies sual acuity. Visual advantages of sodium apor illumination: monochromatic nature ermitting sharp focus; yellow color to which e is more sensitive than to other colors. s a result, eye strain is lessened, vision is

A MINIATURE FREQUENCY METER THAT IS RELIABLE!

This Miniature Frahm Vibrating-Reed Frequency Meter (shown actual size above) is an indicating instrument without moving system or pointer. The operating principle and the method of indication are based on resonant vibration of accurately tuned steel reeds. These instruments are easy to read, ruggedly constructed, surprisingly accurate over long periods of time and are unaffected by wave form or by ordinary changes in voltage and temperature. Available in various ranges of power frequencies from 15 to 500 cycles per second; in fact, the same instrument can have more than one range.

★ "Frahm" Switchboard Frequency Meter—9" Diameter Case. Made with one or two rows of 31 reeds each, for indicating power frequencies, also for measuring frequency of harmonic ringer circuits in telephone work.

★ "Frahm" Portable type Frequency Meter. Mounted in polished walnut case 9¼" x 8½" x 4½" overall, with carrying handle. Wide range, such as 22.5 to 90 cycles per second. Arranged for various potentials from 50 to 300 volts.

Write for illustrated Bulletin 1695-I describing all types shown.

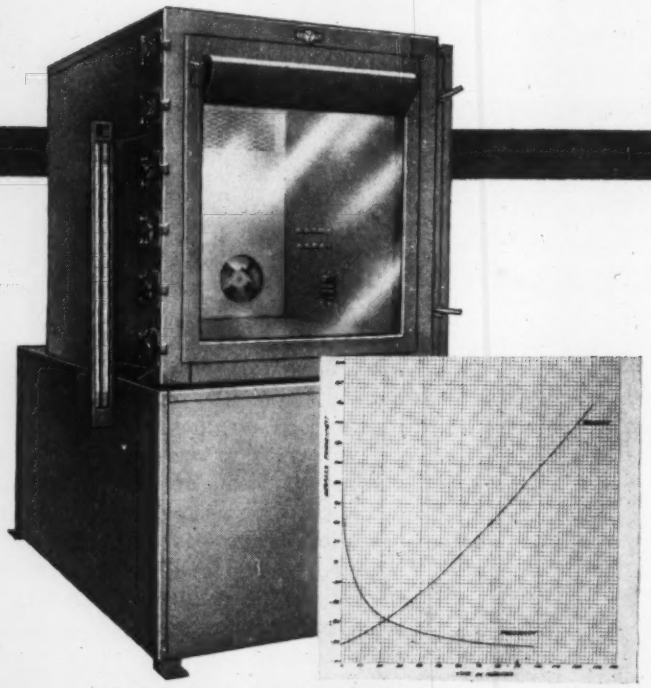
James G. Biddle Co.

1211-13 ARCH STREET *Electrical and Scientific Instruments* PHILADELPHIA, PA.

Flight-similitude Cold Testing

Only *Mobile* units offer program controlled or manually set flight-similitude conditions. These units provide completely coordinated altitude-temperature curves to a maximum of 80,000 feet altitude at a temperature minimum of −100° F.

Reheat and humidity testing is standard also in these *Mobile* units, up to +160° F with fully controlled humidity conditions according to your requirements. Our production time has recently been cut by almost 40%. We invite your inquiry.



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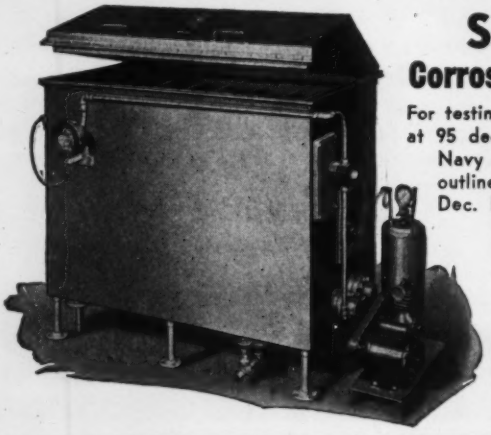

SALT SPRAY
Corrosion Test Equipment

For testing—Electroplated or coated metals at 95 deg. Fah. in accordance with Army, Navy and Aeronautical specifications, as outlined in Bulletin AN-QQ-S-91-5 dated Dec. 1938. Also for controlled temperatures from 65° to 130° Fah. Testing Cabinets lined throughout with rubber. Made in 4 sizes.

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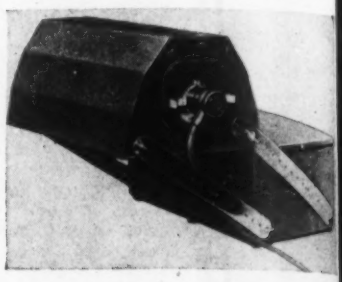
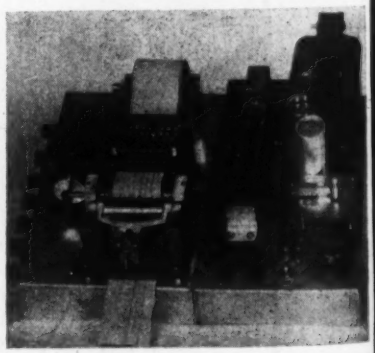
improved, and less intense illumination required. For instance, 100 foot-candles sodium vapor illumination give vi equal to 500 foot-candles of illumina from the entire spectrum, while produc less objectionable glare. New monoch matic light unit employs sodium vapor hence requires no filters. Its illumina discloses minute objects, cracks or marki that are invisible under ordinary light. Si ilar advantages are obtained in microsc



inspection. Other uses: creating interfe ence bands in checking surfaces by mea of optical flats; identification of Z axis concentric ring pattern and observation twinning in quartz crystals; analysis of ganic compounds where readings of rot tion of polarized light are used; micr photography, etc. New units are made several different types, depending upon a plication for which intended. Illustrati above shows "Universal Bench Model," r flector of which can be swung into vario positions in order to direct illumination desired—upward or downward, over a wi field or a narrow field.—*Geo. W. Gates Co., Franklin Square, Long Island, N. Y.*

Multi-element Chronograph

New "Metron Type 4" Multi-element Re cording Timer is a chronograph for recor ing the duration and sequence of time inte vals. Two models are available—"Type 4A for operation from a 6-volt d-c. battery wi a self-contained 60-cycle tuning fork pow supply; and "Type 4B" for operation fro 110-volt 60-cycle a-c. supply. New chron graph uses an electrically sensitive record ing paper so that a clearly visible record immediately available without processing any kind. Record paper is 2" wide. A com plete record consists of eight traces, th two outside traces for timing purposes, th six inside traces for recording purpose



Timing traces consist of a series of dot 1/60 of a second apart. By laying a straigh edge across the record, the exact startin and stopping times of the various traces ca be determined. For continuously monitorin purposes, for example, when monitoring circuit breakers on a power distributio system, motor and tuning fork are kept i operation at all times but paper is not se into motion until first circuit breaker opens Design of the record drive system is suc that recording starts approximately ¼ cycl after circuit breaker opens. For laboratory use, paper is set into motion before tim interval to be recorded starts, and thu there is no delay in recording. Typical use

de monitoring of power distribution
ems, measuring at various points the
ntaneous speed of traveling objects,
g of switches and relays, timing of
rically or mechanically controlled proc-
s and events, and for general-purpose
ratory and field use for measuring time
vals ranging from 1/60 sec. up to 12
tes.—*Metron Instrument Co., 432 Lin-
St., Denver, Colo.*

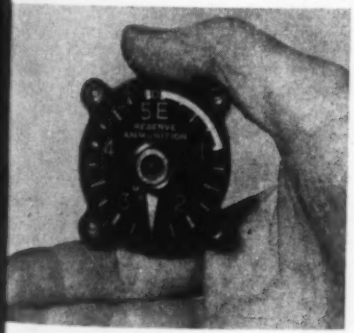
Thermostatic Flow Switch

w Electro-Thermostatic Flow Switch,
resistance welding and other applica-
, detects lack of proper cooling water;
ists of a 100-watt transformer having

e-turn secondary short-circuited through
iece of high-resistance stainless-steel
ng through which coolant flows. A nor-
ly-closed two-pole thermostatic switch
sed. It is available in either a 1 one-
-gallon or 3 one and one-half-gallons
minute size in both a 25- or 50/60-
e 220/440-volt rating. Other voltage
ngs are available by supplying an auto-
nsformer. Furnished with spring mount-
to insure against excessive tightening
switch elements, Electro-Thermostatic
w Switch is available with or without
losing steel cabinet. All parts are easily
ssible for replacements. Mounting space
uired is approx. 7″ wide by 9″ high by
deep.—*Dept. 7-N-20, Westinghouse Elec.
Mfg. Co., East Pittsburgh, Pa.*

mmunition Counter and Gun Malfunction Signal

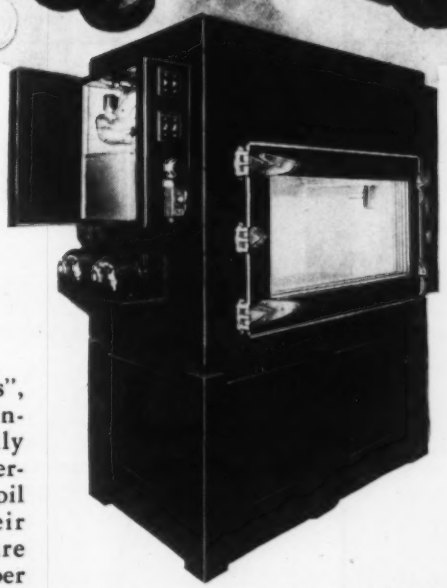
New Ammunition Rounds Counter tells
rator of an aircraft machine gun or
non how many rounds of ammunition he
remaining and whether his weapon is



ctioning properly. It weighs 5 oz. and is
igned to be mounted on any instrument
el and in any desired position. It occu-
s so little space (see photo) that four
ffecting four guns or cannon) may be
unted in a space 3½″ square and a
en in a space 5¼″x7″. A knob in center
dial is used to set pointer for exact
mber of rounds of ammunition with
ich the gun has been provided. As gun
fired, pointer travels towards zero, show-
empty only when last round has been

A DRAMATIC DROP BY MEN AND MACHINES

Parachuting from stratosphere altitudes of over 30,000 feet and sub-zero temperatures often as low as minus 92° F., the pilot drops earthward at an amazingly rapid rate to lower altitudes and higher temperatures.



MODEL RTC-1H
Temp. Range: —55° C. to +70° C. Humidity Range: ambient to 140° C.; ambient to 95% relative. Usable Interior: 25.9 cu. ft.

There are other "fast drops", just as dramatic. For instance, the exceptionally quick pull-down in temperature, distinctive to Amcoil Testing Chambers. Their fast rate of temperature change means more tests per hour and more tests per dollar. As one user so aptly put it, "she goes up and down like an elevator".

Have you the problem of simulating conditions of the upper altitudes and observing their effect upon the behavior of your instruments prior to their use? In addition to temperature test chambers with either mechanical or dry ice refrigeration, Amcoil units are available for humidity testing and altitude testing. Ask an Amcoil Engineer to help you by recommending the correct equipment for wartime pre-testing of your instruments.

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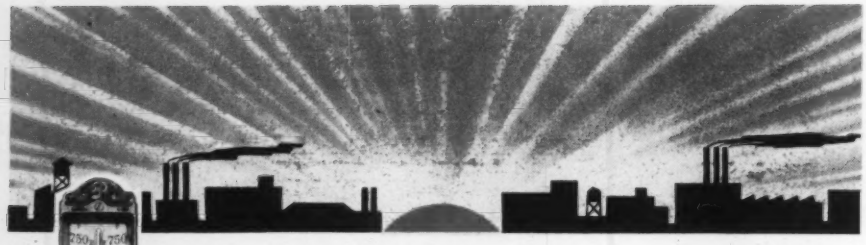

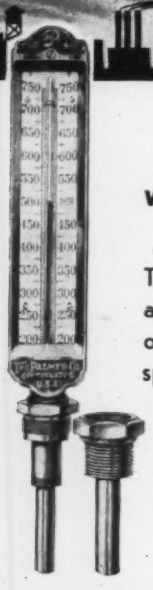

Until the Light Shines Again

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These thermometers must be made to the same high standards for which Palmer Thermometers are famous because only GOOD thermometers will help to win the war more speedily.

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Use of both eyes reveals true depth of details. Magnification of 2¼x. Free working distance, 8" to 10", permitting unhindered use of hands. By just lifting your head, your eyes are free for any other activity. Eyeglasses may be worn while using. Highest optical quality. Black Tenite plastic—practically unbreakable.

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In bakelite mounts. Wide field, high luminosity and excellent definition for close-up examination. Two types: A 6-power magnifier consisting of an aplanatic lens system . . . A 9-power magnifier which has the 6-power system and a 3-power lens. Both may be used singly as 6x or 3x magnifier or in combination, resulting in a 9-power magnification.

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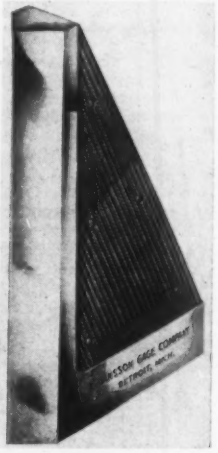
fired. Recessed in center of reset dial small pilot light, electrically connected as to blink with each shot fired. If jams, light will not work; if rate of reduced from overheating or other speed of flickering light is reduced warning to gunner. A fluorescent red around the last 20% of the pointer's serves to warn gunner that his ammu is running low. Pointer's numerals and sions are pale green fluorescent paint a black background. Remote operating mounted on gun or cannon, is actuated the bolt stud with each round fired, electrically connected to the gunner's Current consumption is 0.035 amp. for nal light and 0.06 amp. for actu mechanism. (These values are for short intervals of time.) An override prevents mechanism from over-coun regardless of voltage or acceleration Counter has been tested in maker's lab tories through the equivalent of 1,000,000 rounds with "practically no cation of wear."—*National Machine Products, Los Angeles, Calif.*

Precision Tri-square

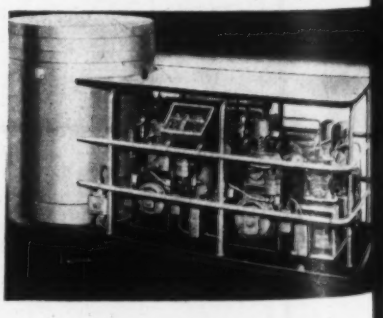
Of one-piece solid construction, "Jansson Master Tri-Square" is said to suited to extreme precision measure wherever 90° angles are involved. Held



limits of 0.00002" on the base and ver side, this tri-square is available in sizes: (1) 6" in height with a base 1" and 4" long; (2) 4" in height with a 5/8" wide and 2-3/4" long. Tri-square ground, hardened, and lapped from steel; has a knife edge on the vertical for easy visual gaging; is provided with inset hard fibre serrated grip to prev heat transfer and to prevent slipping handling. Final manufacturing operati are performed in temperature-control room.—*Jansson Gage Co., 1920½ Glend Detroit, Mich.*

Chilling Unit for Product Testi

New "Model D-70 Deepfreeze" 2-st industrial chilling unit provides a w range of sub-zero temperatures; has maximum capacity of –70° F. and remov



0 b.t.u. per hour at that temperature. illing chamber consists of a double-wall d cylinder which entirely surrounds walls chilling compartment. Cylinder I. D. is , depth is 30". Unit has over 24 ft.² of mary freezing surface and a capacity of gallons; overall height 37", length 67", idth 36". Temperature control is adjusta- from atmospheric temperature to −70°. ecially designed expansion valve is elec- ically controlled. Dehydrator is charged th silica jel. Unit employs 2-stage com- ession and single-stage refrigeration prin- ple.—*Deepfreeze Div., Motor Products rp., 2301 Davis Street, North Chicago, Ill.*

Percentage Timer

New Percentage Timer automatically ntrols the percentage of time at which y a.c. circuit can periodically be closed opened out of a definite length of a time

ycle; is said to be particularly applicable here one function bears a definite time elation in percentage or operation of a econd function such as to regulate any nput to electrically operated furnaces, vens or heaters; controlling the propor- ionate flow of chemicals for boiler feed ater treatment, etc. It has a self-starting ynchronous motor which drives a cam-op- rated switch mechanism through an en- losed gear train. Percentage of operating ime is a function of the motor-driven cam n relation to a similar stationary but ad- ustable cam fixed to a calibrated dial. Timers are available for 7 different time anges from 30 seconds to 60 minutes total ycle. S-p.s-t. contact is rated at 10 amp. t 115 volt or 5 amp. Entire timer is en- losed in a dust-tight molded Bakelite case or flush mounting 3¼" diameter and 9/32" over-all length. It also can be fur- ished with various types of surface mount- ng steel connection boxes.—*The R. W. Cramer Company, Inc., Centerbrook, Conn.*

Gage-block Case

New case for "Doall" Gage Blocks, only ne-fourth as large as conventional type age block case, holds the 81 precision locks in full view of user. In addition, locks are arranged for easier removal and election. Each block is placed at a slight ngle in case, so that etched size marking ear top of each block can readily be seen

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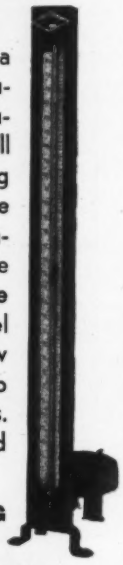

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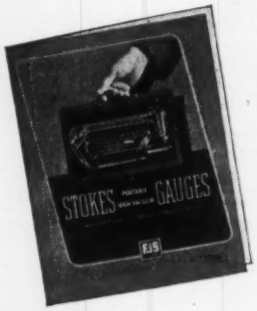

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6008 TABOR ROAD, Olney P.O., PHILADELPHIA, PA.

at normal viewing angle. Proper positio for each block in case is marked corre sponding to size marking on block. Box kiln-dried solid walnut, properly treated t insure against acidity from wood affectin highly polished surfaces of gage block Dimensions 11" × 4½" × 2". New box ca be stored in drawer of a machinist's too box. Convenience of handling lessens hazar of dropping on floor and damaging lappe surfaces of blocks. All standard sets of "Doall" Gage Blocks will be supplied i new case, although conventional flat typ box may still be obtained.—*Savage Tool Co 123—14th Ave., Minneapolis, Minn.*

Multi-deck Switch

New multiple deck switch for line volt age selection for transmitters, productio control test boards, or other electrical in strument or pyrometer service, is said t offer a large number of contacts in smal

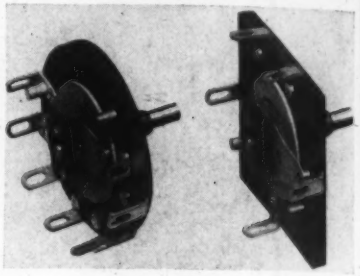


Fig. 1

space. It can be furnished with one to six decks with a maximum of 23 contacts and off position per deck making possible up t 138 contacts with a six-deck unit. Switch will handle a current capacity up to 25 am peres. Single-deck type can be furnished with either square or round type bases, but where more than 8 contacts are needed the round type is furnished. Bases, 3" overall

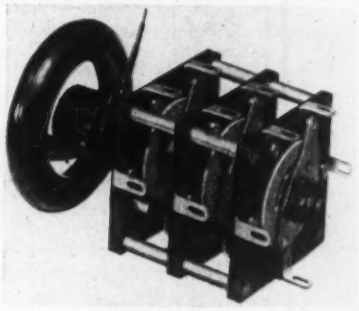


Fig. 2

are of fabric-base Bakelite. Contacts are turned of pure silver rod. Lugs and other metal parts of either brass or steel are sil ver-plated for rust-resisting. A selector knob or handwheel is furnished if desired, as is also an engraved numbered switch plate.—*Electric Service Products, 1322 So. Grand Ave., Los Angeles, Calif.*

Furnace Atmosphere Analyzer

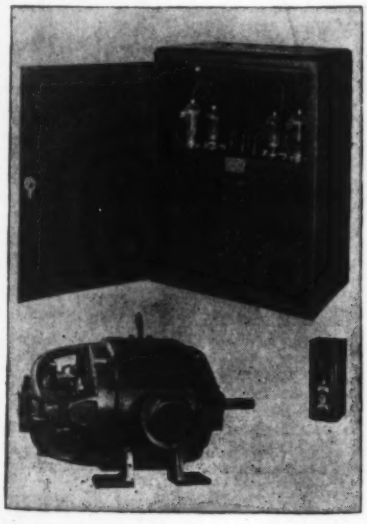
New "Furnace Atmosphere Indicator" employs thermal conductivity method of analysis described by Palmer and Weaver in *Technological Paper No. 249* of National Bureau of Standards. Its use, it is claimed, makes possible setting up an easily-followed standard for practically all furnace operations. Ideal atmosphere for a given operation can be determined and subsequently reproduced for any similar operation by adjustment of furnace's air-fuel ratio to give the same indicator reading. Indicator is in continuous operation during entire heating cycle, enabling operator to detect any at-

nosphere change of consequence which may take place by reason of variations in the gas supply. Importance of this point is stressed because city and mixed gases vary from time to time, as do atmospheres pro-

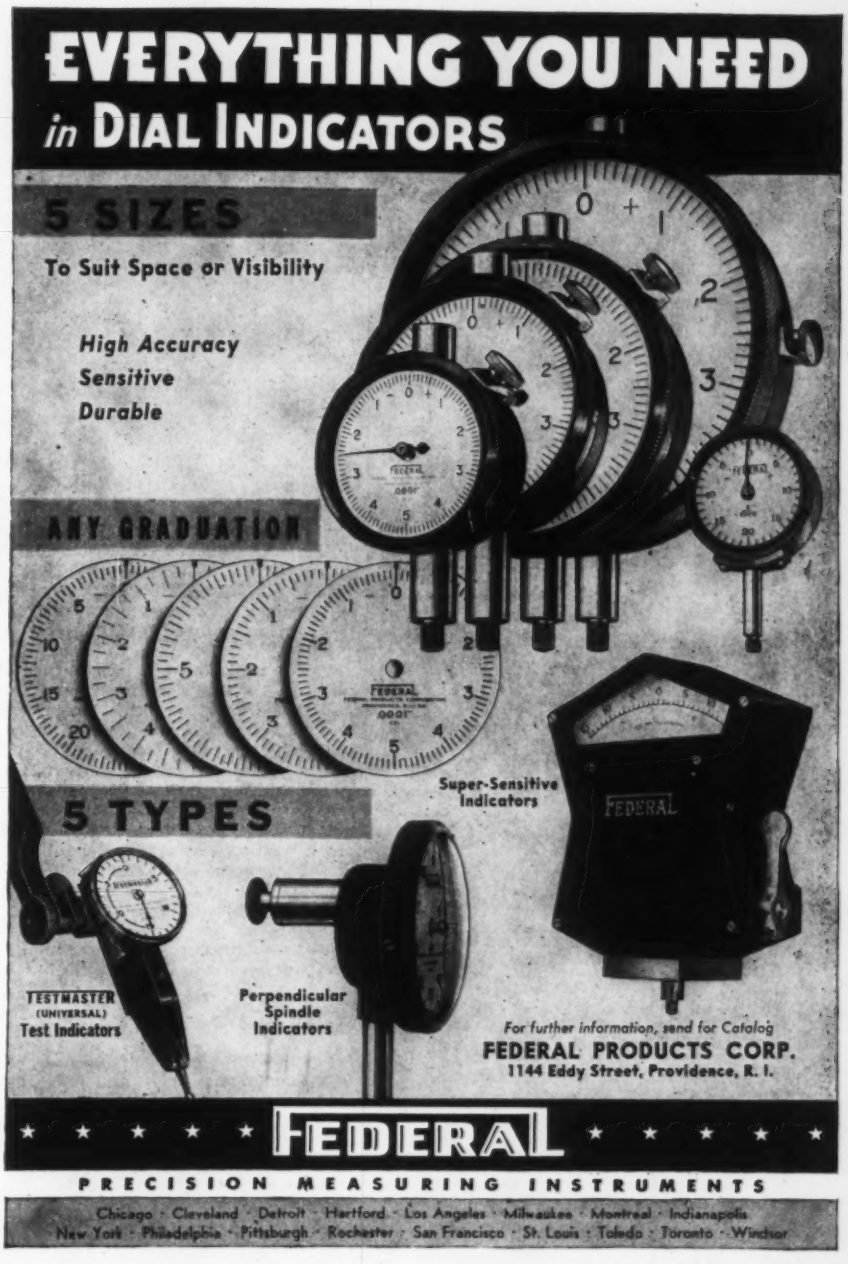
duced in some generators. A further claim is that, on many furnace operations, fuel saving made possible is more than enough to justify cost of instrument "over a short period."—Developed and manufactured by *Weaver Mfg. Co., Springfield, Ill.*, sold by *Claud S. Gordon Co., 3000 S. Wallace St., Chicago, Ill.*

Adjustable-speed Controller

New "Mot-O-Trol" is an electronic adjustable-speed controller for application on industrial drives, such as machine tool feeds, winding reels, conveyors, and fabricating



and converting machinery. It is said to provide close speed regulation over a 20 to 1 speed range for d-c. motors operating from an a-c. source. Features are said to include stepless speed control, automatic close speed regulation over wide load fluctuations, full torque at extremely low speeds, smooth stepless acceleration and deceleration and dynamic braking. At present, a standard "drive" (as this control system is termed because it replaces belt drives, m-g. sets, etc.) is available for ratings up to 1 hp. for single-phase operation on 110- or 220-volt 60-cycle supply. Special drives of larger horsepower rating can be designed to suit particular application requirements. New system has four parts: (1) power transformer for separate mounting, (2) Mot-O-Trol cabinet with thyratron tubes and current limiting and speed regulating control, (3) control station with potential divider to vary the voltage supplied to the armature and field circuits and with start and stop push buttons, and (4) shunt-wound d-c. motor. The standard Mot-O-Trol is designed to automatically regulate a preset motor speed so as to maintain essentially constant speed regardless of load. The d-c. voltage output of the main rectifier tubes is controlled by small tubes to compensate for speed changes. For a speed range of 10 to 1, with torque varying from no load to full load, speed will not vary more than 4% from a preset value. Maximum variation for the 20 to 1 speed range is within 8%. Control is arranged so that motor is always started at full field regardless of speed setting. If speed is set above base speed, with weakened field, speed control does not become effective and field is not weakened until motor reaches base speed. Fast, smooth acceleration is said to be automatically obtained through special current-limiting device built as part of standard unit. This current-limiting device also works from a small auxiliary control tube that in turn controls firing of main rectifier tubes. Thus, voltage output of rectifier will be such that a preset current limit will not be exceeded. For general applications, current-limiting device may be set over a wide range up to 200% of rated full-load motor current, so that accelerating characteristics may be varied to suit load conditions. If unusually high starting currents are required, rectifier tubes must be carefully chosen for their peak ampere rating, even though running load conditions do not exceed average ampere tube rating. Motor is quickly stopped with a dynamic braking resistor that is not in the motor circuit during running conditions. Amount of braking resistance is adjustable. Vibration difficulties sometimes encountered with adjustable-speed drives have been minimized, as the d-c. motor is only rotating part. No separate line starter or field rheostat is required. Electronic control may be mounted in its own cabinet or installed directly on or in driven machine.—*Dep't 7-N-20, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Penna.*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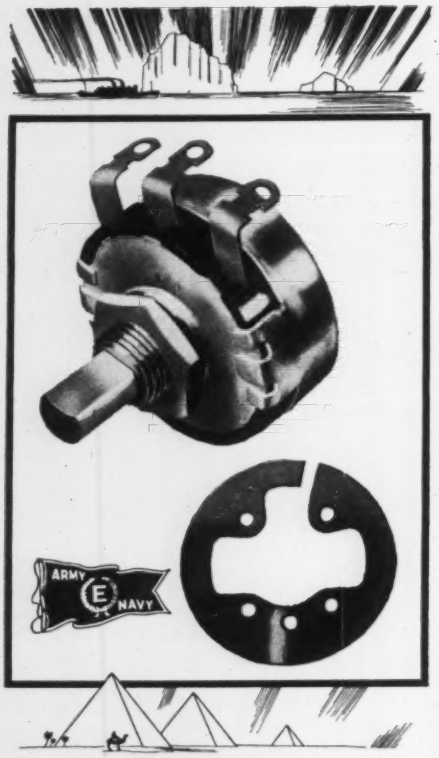

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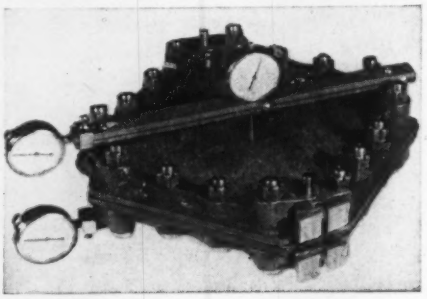
Fixture for Testing Plywood Panels in Shear

To obtain data on shearing stresses of plywood, new fixture provides means for subjecting a small panel to uniform shearing stress—insofar as it does not buckle. Some research workers think that this provides a particularly good means for estimating by tests the seriousness of the pres-



ence of certain defects that may be present in the plywood. It is a comparatively new method of general investigation of plywood and seems likely to yield a considerable amount of good information regarding how plywood of various constructions acts in shear. It requires little special training for workers to make accurate tests of plywood in shear by using this fixture. A template supplied with the fixture makes it a simple matter to prepare plywood testing samples. Because of simplicity in preparation of sample, assembly of parts, and in making test, new method can be used readily and repeatedly at low cost. In order to adapt fixture to available equipment, bearing blocks are designed to permit testing a specimen under diagonal loads either in tension or in compression.—*Streeter-Amet Co., 4101 N. Ravenswood, Chicago, Ill.*

Relay and Switch Test Units

New "Type FT Flexitest" cases for panel mounting combine a relay and knife blade test switches in the same unit, with maximum flexibility in maintenance and testing.

Standard relay elements are mounted on a removable unit chassis. Test connections can be made either by clip leads or test plug. Test switches are of high-capacity self-aligning knife blade construction with movable blade and hinge jaw mounted on a molded block rigidly fastened to case. Each circuit can be identified by cards on switch handle; a red handle identifies the trip circuit. Three sizes are available. All have a metal cover with a transparent window for visual inspection of elements and observa-

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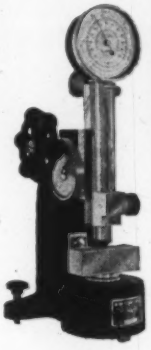

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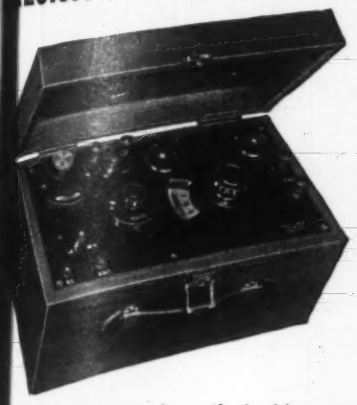

ailable in a number of double-range nbinations, such as 1 volt and .1 volt, 0 MV and 10 MV, also in pH ranges. aranteed accuracy .1%. *An outstand- value.*

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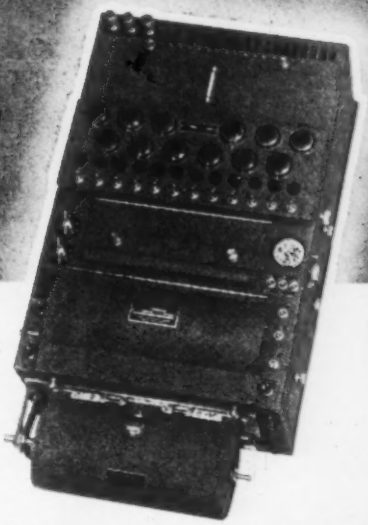

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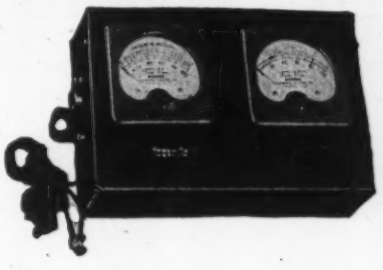

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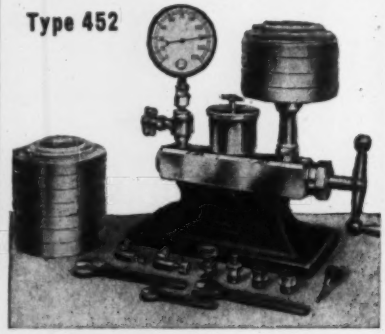

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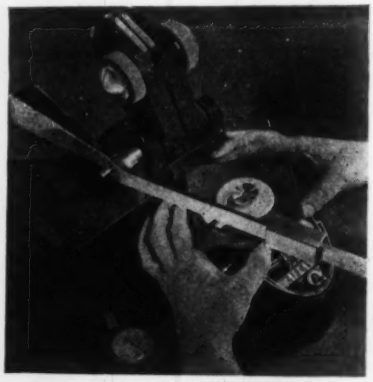
tion of relay targets.—*Dept. 7-N-20, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.*

Shear-hardness Tester

New "Shear-Hardness Attachment" for "Taber Abraser" (*Instruments*, Sept. 1937, page 227; July 1939, page 172; May 1940, page 123; March 1941, page 64; June 1942, page 230) permits measuring toughness quality of surface finishes and their ability

to resist digs, scrapes and similar abuse from actual service not considered normal wear. A weight slides along a calibrated beam until it is finally located in the position where correct load permits tool point to cut a groove in surface finish without digging through to base plate. Several

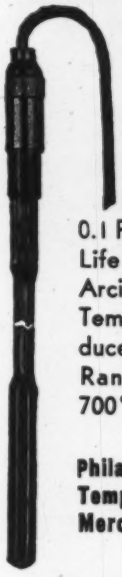


grooves are made in the surface and the most representative one is selected to measure to the nearest thousandth of an inch. A special Taber micrometer is furnished to make this measurement. Shear-hardness of specimen is calculated by taking reading from calibrated beam at forward edge of adjustable weight which together with width of groove determines the result by a mathematical formula. A 4" square sample is sufficient. Apart from this new function, "Taber Abraser" evaluates resistance of surface finishes to rubbing abrasion: wearing action by "Calibrase" wheels on specimen clamped to revolving turn-table is measured in terms of "wear cycles" which are automatically totaled on built-in counter.—*The Taber Instrument Corp., North Tonawanda, N. Y.*

Dynamotors

Supplementing maker's "Super Genemotors" and "Heavy-duty Genemotors," there is announced a complete line of single, double, and triple output "Dynamotors". These multi-dynamotors eliminate the conventional two dynamotors in all two-way transmitter and receiver installations, by combining both machines in one unit. This, of course, reduces weight considerably and also reduces cost and possibility of trouble. —*Carter Motor Co., 1605 Milwaukee Ave., Chicago, Ill.*

Philadelphia Merc-to-Merc Thermo-Regulators Feature



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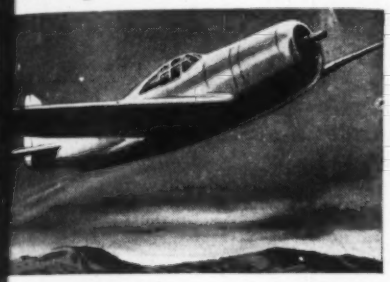
limbing, gliding, zooming—these y dials "hear" and "see" the things e pilot's got to know. Mixture. Gen- ator. Radio. RPM. They must have e pilot's confidence. The instruments *ust* be right.



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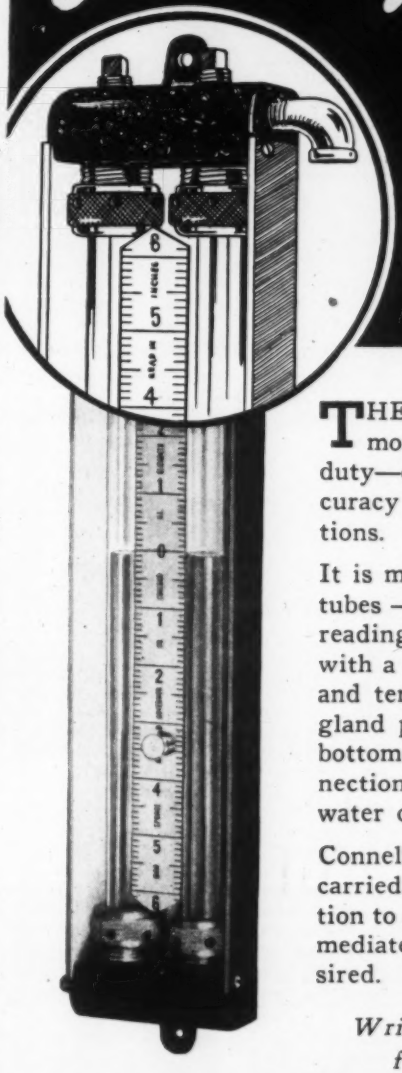

THE New Connelly Manometer, model 3400—built for extra heavy duty—can be depended upon for accuracy and long life under all conditions.

It is made with large bore, clear glass tubes — ¾" in diameter — for easier reading even at a distance. Supplied with a scale graduated either in inches and tenths or in metric measure. It is gland packed, with drain plugs at the bottom and is fitted for ⅛" pipe connections. Made for use with either water or special anti-freeze solution.

Connelly Model 3400 Manometers are carried in stock in five sizes. In addition to these stock sizes, larger or intermediate sizes can be supplied if desired.

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27 PARK PLACE NEW YORK, N. Y.

WRITE FOR BULLETIN No. 430

EDITORIAL—*Concluded from page 329*

"Let us take, for example, just one new industry, electronics. . . . The amplification of minute forces by means of electronic tubes offers endless possibilities for the development of new and useful devices in the post-war years. Television is in its infancy. . . . Landing fields for planes will be equipped with the Radar and incoming pilots advised of their exact location. The day may come when passenger planes will be equipped with the Radar to avoid collisions with other planes or mountains. . . .

"I mention these examples of electronic developments to illustrate the possibilities for tremendous post-war business in the production of new devices of this character.

"When the war ends, we will have thousands of plants which have been producing to the maximum to turn out the necessary war materials and we will have many hundreds of new plants built during the war to supply our Armed Forces with the planes, guns, tanks, ships and other equipment. The Defense Plant Corporation, for which I have served as regional consultant in this area, has furnished the money to build and equip 1500 new plants. How can we best utilize all these new plants after the war?

"First of all a study should be made now, not when the war ends, as to peace-time articles which can be best made in these plants and we must start now, not when Hitler has surrendered, to develop new devices which the people of this great nation will need when peace reigns again.

"The welcome mat awaits the inventor. Never before history has the time been so ripe for new inventions. T American people are counting on our inventors, whet working in the cellar of their home or in the million do laboratory, to keep the post-war ghosts out of our factori

"One way in which you can help in preparing for t post-war era is to become an inventor yourself. . . . The i that inventors are born is a fallacy. . . .

"Many new ideas and inventions will appear on the m ket after the war. Thousands and thousands of people w be put to work producing these devices which will ma living more comfortable and more complete.

"You have probably never thought about it, but you c do some inventing yourself if you try.

"And as you go through life, may I urge that you take interest in politics, for in a democracy such as ours, we w have good government or poor government dependent on t interest which our citizens take in government.

"And now a suggestion from a man who has been throu the mill. Today as never before, our industries are seeki men and women with executive ability. Do not hesitate assume responsibility, when you are given the opportuni Some people shy away from responsibility for fear of ma ing a mistake. Better assume responsibility, even thou you may occasionally make a mistake, for it is those w are willing to assume authority and responsibility, who a in demand as leaders."

Instrument Societies

NEWARK

The regular monthly meeting of the Society for Measurement and Control of New Jersey was held Tuesday evening, June first, at the Public Service Terminal Restaurant, Newark, New Jersey. In spite of gasoline rationing and inclement weather, the attendance was by far the largest of the year, definitely showing the increased interest in instrument control of industrial processes.

Mr. J. B. McMahon, Control Engineer, Republic Flow Meters Company, was the speaker of the evening. The subject covered a comparison of automatic control requirements in boiler plants and in the process industry. He pointed out the industrial control applications for which boiler control equipment could be suitably adapted. He covered details of construction and the basic principle of balanced forces underlying this type of equipment.

The discussion which followed dwelt with the application of control instruments to process work and interested everyone.

NORTHERN INDIANA

On Tuesday evening, June 2nd, the Northern Indiana Society of Measurement and Control was organized by nearly forty-five instrument men in the Calumet Region.

The organization meeting was preceded by a dinner, after which the following officers were elected: Eugene Bainbridge, President; George E. Fischer, Vice President; Charles H. Bailey, Recording Sec'y; Lester Johnson, Treas.; Ray W. Schreiner, Corresponding Sec'y, 4 Waltham Street, Calumet City, Illinois.

The guest speaker for the evening was V. H. Hiermeier of the Brown Instrument Company who also has most of the members in an Automatic Control class under the Purdue University War Training Program. The subject was "Post War Application of Industrial Electronic Instruments."

One unusual point about the members is that they are all actually instrument mechanics and will likely restrict their active membership to that classification. The second is that all but four of the charter members subscribe to *Instruments*.

Several committees have already been selected. No definite date is fixed as yet for the next regular meeting, but it is planned to hold regular meetings each month.

Most of the men forming this new organization have attended the Chicago Society for Measurement and Control but find d ing these times of longer hours and gasol rationing, that it is practically impossi to attend those meetings in Chicago.

PHILADELPHIA

It surely was a hot night in Philadelph —temperature 86°, humidity 74, and pe spiration flowed freely. Attendance fell accordingly but, for the benefit of those th missed the meeting, we want to state th it was one of the most interesting.

Mr. Packard, Manager of Field Engine ing of Struthers Dunn, Inc., was the speak and his subject was "The Relay as an I strument Auxiliary," which dealt with t design and operation, and application various types of relays. Mr. Packard al had slides showing fundamental circuits, e

Illustrations ranged from the tiny sens tive, to the high-voltage or frequency type and those that must operate under seve vibration or shock, such as encountered electrical apparatus aboard battleships.

The auxiliary relay has come a long wa in the past few years, and with electron derivations moving along at the war pac we can expect further refinements.

City	Society and Secretary	Date	Place	Subject	Speaker
Atlanta	Georgia Society for Measurement & Control D. D. Beach, P.O. Box 4569, Atlanta, Ga.				
Baltimore	Baltimore Industrial Instrumentation Society Fred Pullen, Bethlehem Steel Co., Sparrows Point, Md.				
Chicago	Chicago Society for Measurement & Control Carl Hope, 2626 W. 31st Blvd., Chicago				
Hartford	Hartford Society for Measurement & Control Stephen J. Zelle, Whitney Chain & Mfg. Co., Hartford, Conn.				
Newark	New Jersey Society for Measurement & Control R. F. Robey, 409 Orange Ave., Cranford, N. J.	Oct. 5(C)	Public Service Terminal Restaurant	Application of Null Principle	C. B. Moore, Pres. Mo Products Co., Philadelphi
New York	New York Society for Measurement & Control R. K. Farnham, 545 Fifth Ave., N. Y. C.	June 29(B)	Churchill's Terminal Restaurant	Machines, Men and Meters	R. J. Kryter, Vice-pres Esterline-Angus Co.
N. Indiana	Northern Indiana Soc. Measurement & Control R. W. Schreiner, 4 Waltham St., Calumet City, Ill.				
Philadelphia	Philadelphia Society for Instrumentation George Hammer, 712 Otis Bldg., Phila., Pa.	June 16(B)	Engineer's Club	Rotameters and Their Secrets	Kermit Fischer, Pres., Fischer & Porter Co.
Pittsburgh	American Society for Measurement & Control L. M. Susany, c/o Carnegie Institute, 4400 Forbes St., Pgh.				

(A)Meeting at 7:30, no dinner. (B)Dinner at 6:30, meeting at 8. (C)Dinner at 7, meeting at 8. (D)Meeting at 8, no dinner.

Manufacturers' New Literature

In this department we report ALL pieces of new literature pertaining to Instrumentation, ceived from the manufacturers. To assist in the War Effort we urge readers to request ONLY se bulletins which will be of value to them. Use the coupon on this page.

K-170 **Insulation Testers.** Bulletin 25, 8" × 10", 4 pages covers the first legger" instruments of American manacture. These instruments are housed molded Bakelite cases. James G. Biddle , 1211 Arch St., Philadelphia, Pa.

K-171 **Ground Glass Spherical Joints.** lletin 42-SJ, 8½" × 11", 2 pages lists d gives prices on various sizes. Greiner assblowing Laboratory, 255 W. Santa rbara, Los Angeles, Calif.

K-172 **Capacitors.** Catalog V-1, 8½" 11", 4 pages lists standardized capacrs for civilian radio replacement rts. Solar Capacitor Sales Corp., yonne, N. J.

K-173 **Automatic Control.** Bulletin 118, " × 11", 4 pages illustrates and fully cribes the hydraulic jet pipe principle automatic control. This folder clarithe principle, the advantages, and functions of the jet pipe and is of erest to engineers coping with intrie and critical control problems. Asnia Regulator Co., 1603 S. Michigan e., Chicago, Ill.

K-174 **Inspection Laboratory.** Folder, × 12", 4 pages fully describes the herr Limited Budget Inspection Labtory. Fourteen types of measuring inruments, tools, gages and optical inction devices are briefly described in folder. George Scherr Co., 128 Lafayte St., New York, N. Y.

K-175 **Electro-Chemograph.** Bulletin 94(1), 7¾" × 10½", 16 pages, pices the latest improvements in the ctro-Chemograph dropping-mercuryctrode equipment. Principal new feaes are: (1) The capacity of the mery reservoir is considerably increased, d (2) a pressure-adjusting bulb is ded. Object of these changes is to fatate the holding of a uniform level of rcury, so that it is comparatively easy maintain the dropping rate within ired limits. The electrode holder has o been re-designed for greater conience of the user. Leeds & Northrup , 4934 Stenton Ave., Philadelphia, Pa.

K-176 **Telemetering.** Industry Data eet 39, 8½" × 11", 12 pages, describes Metameter Telemetering installations d by the Washington Gas Light Comny, Dallas Gas Company, Arkansas uisiana Gas Company, Portland Gas & ke Company, Zenith Gas Company, d Citizens Gas & Coke Utility as exples of how, many gas companies are ng the Metameter System of Telemeing in controlling and keeping close ck on distribution pressures. Bristol , Waterbury, Conn.

K-177 **Temperature & Pressure Indiing & Recording Controllers.** Catalog 0, 8½" × 11", 42 pages, illustrates and cribes many models. Features are iltrated as well as a large number of ual installations. C. J. Tagliabue Mfg. , Park & Nostrand Aves., Brooklyn, Y.

K-178 **Ohmite News.** The April issue a very interesting biography of Nia Tesla. Ohmite Mfg. Co., 4835 Flour St., Chicago, Ill.

K-179 **Battery Charger.** Bulletin DL 263B, 8½" × 11", 8 pages, describes a nstant potential battery charger for ephone service. It is a dry disk rec with a control circuit which mains a substantially constant d-c. volt output at any load, in the presence wide changes in a-c. input voltage. ytheon Mfg. Co., 190 Willow St., Walm, Mass.

K-180 **Radio Products.** Catalog 500, 8½" × 11", 20 pages, catalogs dials & knobs, condensers, coils, sockets, insulators, plate & grid grips, cabinets, shields, oscilloscopes, transformers, chokes, power supplies, amplifiers & modulators, transmitters and receivers. National Co., Malden, Mass.

K-181 **Insulation Testers, Tachometers & Rheostats.** Bulletin 1720, 8½" × 11", 12 pages, briefly describes Biddle specialties in industrial instruments and scientific apparatus. James G. Biddle Co., 1211 Arch St., Philadelphia, Pa.

K-182 **Analysis of Noise.** The April issue fo the General Radio Experimenter covers the analysis of noise as Part VI of The Noise Primer. It also contains an article "Methods of Obtaining Low Distortion at High Modulation Levels." General Radio Co., 30 State St., Cambridge A, Mass.

K-183 **Low Temperature Refrigeration Requirements in War Production.** Reprint from **Refrigerating Engineering** describes new methods in handling aluminum alloy rivets, in the aging of metals, in expansion fit assembly of machined parts, and in testing aircraft instruments. Servel Inc., Evansville, Ind.

K-184 **Precision Cleaning.** Booklet, 8" × 5½", 8 pages, gives composite answers to a recent questionnaire on the use of precision cleaning machines and solutions. L & R Mfg. Co., 54 Clinton St., Newark, N. J.

K-185 **Crystal Orientation.** Bulletin 202, 8½" × 11", 2 pages, offers an x-ray quartz analysis machine equipped with two goniometers. The use of two goniometers almost doubles the volume of crystals that can be handled by one analysis machine. Machines already in use can have their usefulness increased by replacement of the natural face orientation table with a goniometer designed for use on the left side of the machine. Philips Metalix Corporation, 419 Fourth Ave., New York, N. Y.

K-186 **Industrial Radiography with Radium.** Manual, 6" × 9", 80 pages, is designed for beginners in the field of industrial radiography with radium—a thoroughly tested and approved method of non-destructive inspection. Canadian Research & Uranium Corp., 630 Fifth Ave., New York, N. Y.

K-187 **21 Electric Gages to Aid Production.** Leaflet GEA-3991, 8" × 10½", 8 pages, describes the functions of the 21 gages, and contains a chart showing schematic representations of electric gage circuit applications. Included among the gages described and illustrated are thickness, magnetic, Electrolimit, pressure, strain, and eccentricity gages. General Electric Co., Schenectady, N. Y.

K-188 **Humidity Test Chamber.** Folder, 8½" × 11". RTC 1-H embodies as an integral part, equipment for mechanical refrigeration and electric heating which afford an unusually fast rate of temperature and humidity change. Its temperature range is −55° C. to +70° C. (−67° F. to +160° F.). Other features include the use of a two-stage Freon condensing unit and special refrigeration accessory developments that make possible extremely flexible operation at various loads and temperatures. American Coils Co., 25 Lexington St., Newark, N. J.

K-189 **Time Delay Relays.** Bulletin 800, 8½" × 11", 4 pages, describes a synchronous motor driven time delay relay, which provides an adjustable or fixed time delay between the closing of a control circuit and subsequent closing or opening of a load circuit. R. W. Cramer Co., Inc., Centerbrook, Conn.

K-190 **Measuring & Control Instruments.** Bulletin Z 6200, 8½" × 11", 16 pages, is a new issue of the condensed catalog, and gives current prices and short descriptions of all Wheelco instruments. The bulletin refers to other bulletins issued to cover particular instruments. Wheelco Instruments Co., Harrison & Peoria Sts., Chicago, Ill.

K-191 **Precision Timers for Time Study.** Leaflet, 4" × 8½", 6 pages, illustrates three stop watches: a 1/10th second with 10 minute register, a 1/5th second with 30 minute register and a 1/100th minute timer, with 30 minute register. All watches use continuous running movement. The leaflet states that these timers are seeing service on every front and with combat needs being cared for, Elgin is now able to supply these watches to industry. Elgin National Watch Co., Elgin, Ill.

K-192 **Flow Rate Meter.** Bulletin 101, 8½" × 11", 2 pages, announces the Rota-Sight, a new flow rate meter for protection against low flow or excess flow. Fischer & Porter Co., Hatboro, Pa.

K-193 **Burrell Technical Announcer.** The spring number of this house organ has a brief article on Butadiene rubber. Burrell Technical Supply Co., 1936 Fifth Ave., Pittsburgh, Pa.

K-194 **Automatic Starter for Internal Combustion Engines.** Bulletin, 8½" × 11", 8 pages, describes the Autotrol de-

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